THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE VI. VOL. IV.

No. VI.—JUNE, 1917.

ORIGINAL ARTICLES.

I.—The Glacial Controversy in New Zealand.

By C. T. Trechmann, M.Sc., F.G.S.

THE controversy which has arisen in recent years in New Zealand regarding the problem of the Pleistocene glaciation of that country resolves itself into the two following main questions:—

1. Was there any glaciation in the North Island?
2. Was there an ice-sheet covering the South Island?

The discussion reached a culminating stage in the year 1909, when papers by Professors P. Marshall [1] and J. Park [2] appeared setting forth the two opposing views. These views have been further summarized more recently in general works dealing with the geology of New Zealand.

Professor Park [3] states that New Zealand was glaciated as far north as latitude 39°, an area which includes the southern half of the North Island and the whole of the South Island, where, he says, the ice reached not only the west coast but also the existing strand of the east coast.

Professor Marshall [4] declines to admit any evidence of glaciation in the North Island. He holds to the view that there was nothing in the nature of an ice-sheet in New Zealand, and that the glaciation of the South Island was a phenomenon confined to certain areas, in fact essentially an extension of the very restricted glaciers which exist at the present day. He speaks,[5] however, of the Taieri schistose conglomerate on the east coast of Otago, on which the supposed evidence of an ice-sheet largely rests, as a glacial moraine, though his remarks make it clear that he is in some doubt as to its true age and mode of occurrence.

Totally independent evidence from the botanical point of view against New Zealand having experienced in recent times an ice-sheet similar to that which covered parts of the northern hemisphere is published by Geo. M. Thomson.[6] The botanical evidence certainly

[1] "The Glaciation of New Zealand": Trans. N.Z. Inst., vol. xlii, pp. 334–48, 1909.

[2] "The Great Ice Age of New Zealand": Trans. N.Z. Inst., vol. xlii, pp. 589–612 and 575–588, 1909.

[3] *Geology of New Zealand*, 1910, p. 182.

[4] Ibid., 1912, p. 202.

[5] Ibid., 1912, p. 203.

[6] "Botanical Evidence against Recent Glaciation of New Zealand": Trans. N.Z. Inst., vol. xlii, pp. 348–53, 1909.

seems to carry great conviction, though I am not competent to offer any useful opinion on this matter.

Other New Zealand geologists appear to adopt an attitude of neutrality, or so far as they have expressed any opinion on the subject seem to lean towards the view that the glaciation was of a localized and not of a regional character.

The glacial or reputed glacial sections and boulders I have actually seen in New Zealand are comparatively few, but in so far as they affect the questions above-mentioned they are important and critical ones. The evidence of a general nature dealing with the two contending views has been so thoroughly put forward in the papers quoted that to go into it would merely be repeating what has already been written, so I shall confine myself to giving my own interpretation of the sections I visited.

Taking the question of the North Island first, Professor Park says in his *Geology of New Zealand*,[1] where he devotes many pages to a detailed description of the various sections, "In the Rangitikei watershed there is a glacial moraine of great extent composed of andesitic blocks torn from the higher slopes of the volcano Ruapehu and transported across the Rangitikei divide into the lower Hautapu valley. This conspicuous moraine sheet is spread over the denuded surface of marine clays of Pliocene age." He speaks of this as the Hautapu or older glacial drift and the Hautapu till.[2]

When I was in New Zealand in 1915 I heard that Professor Park had found one of these andesite boulders bearing striæ which placed its glacial origin beyond question. I mentioned this matter to him when I had the pleasure of meeting him, and he kindly gave me instructions as to where I could see the boulder. Professor Park has recently described this boulder in detail,[3] and gives an excellent photograph both of the whole mass and a nearer view showing the scratches on it.

This boulder bearing the scratches is of prime importance because it seems to me that the question of the glaciation of the North Island practically stands or falls with this boulder. If the scratches are not glacial the boulder is not glacial, and if this boulder is not glacial none of the others are glacial, and the chief evidence for a glaciation in the North Island fails.

I came away convinced that the scratches on the boulder are not glacial, and that they could have been and were caused by other means. I do not desire in any way to appear to take sides in this controversy, but with due respect to Professor Park's opinion I must say that I differ from him as regards the mode of origin of the striations on this boulder.

It is situated on the slope of a hill on the south side of the entrance of a railway tunnel south of Mangaweka station, several hundred feet above the deeply cut gorge of the Rangitikei River, and about 35 miles south-south-east of the summit of Ruapehu. It measures about 14 × 8 × 6 feet, and must weigh about 35 tons.

[1] *Geology of New Zealand*, 1910, p. 183.
[2] Ibid., 1910, p. 205.
[3] Trans. N.Z. Inst., vol. xlviii (N.S.), pp. 135–7, 1915.

Professor Park says the whole of the under side of the boulder is scratched, but when I was there the vegetation round about it was very thick, but that portion of the under surface which I saw is clearly scratched. The surface of the boulder is much decomposed and weathered, and the little crystals composing the andesite can be rubbed off with the finger-nail, and in fact the surface can almost be scratched with the finger-nail, and scratches can easily be made on it with a knife blade.

The boulder rests on a slope and has evidently moved down from higher ground and must move further down in the future towards the river. The scratches could, in my belief, easily have been made by the movement of the boulder over gravelly soil or over other stones. Glacial scratches could not have survived the weathering to which the surface of this boulder has evidently been subjected.

It is true that on the summit of Ruapehu at the present day there exists a small glacier or ice-field at an altitude of from 7,000 to 9,000 feet, but there is nothing to show that it was ever more extensive or that Ruapehu had attained its present altitude in the Pleistocene period. Professor Marshall has pointed out that the slopes of the volcano show no evidence of former glaciation.

The question certainly arises as to how these large andesite boulders come to be scattered over the countryside in such numbers west and south-east of the parent volcano down the Hautapu Valley. Until the district has been accurately surveyed and their distribution mapped it is difficult to say what was the actual mode or direction of transport. They seem to be relics of former gravel or boulder beds which have survived and in some cases become isolated owing to their large size, but exactly at what period the beds were deposited cannot be asserted at present.

I may point out here that it rests with the upholders of a glacial origin for any beds to show that the phenomena cannot have originated in any other way than by glacial action. If their opponents cannot exactly explain the mode of origin of certain deposits it does not necessarily follow that the beds are glacial.

The deep and immature rock valleys seen in the southern part of the North Island, and especially round and near Wellington, are the very converse to what one would expect to find on the ice-sheet hypothesis. Under ice-sheet conditions they would have immediately been filled up with glacial debris.

Turning now to the South Island, the evidence that there was anything in the nature of an ice-sheet rests primarily on some deposits near the east coast of Otago. The largest of these is called the Taieri or Henley moraine. Professor Park describes it as the largest and most important pile of glacial drift in New Zealand. It forms the range of hills bounding the eastern side of the Taieri Plain, and rests against a ridge of mica-schist which separates that plain from the sea and rises to a height of 1,000 feet above sea-level. It extends from Allanton, 15 miles south of Dunedin, to a point in the Clutha Valley, a distance of about 25 miles. Material very similar to that which composes the Taieri "moraine" also forms the celebrated Blue Spur near Lawrence, which Professor Park also describes as glacial

drift and which has long been worked for gold, and there are other outliers of a similar schistose conglomerate. In the Taieri Hills the more or less bedded material dips west at various angles. Professor Park states that the dip is towards the north-north-west for a distance of 2 miles at angles of 10 to 33 degrees. Its thickness is also very considerable, reaching apparently 1,500 feet. In addition to being tilted and faulted it has suffered prolonged erosion, and the deep valley of the Taieri River has been cut right through it.

The Dunedin–Invercargill railway skirts the western side of this chain of hills for over 20 miles, and it forms a very conspicuous feature of the topography.

If these hills were glacial—and when plotted on a map the outline of this rock certainly suggests in shape a great terminal moraine stretching parallel to the coast for many miles—then there must indeed have been a vast ice-sheet debouching from the Alpine region towards the east coast.

I am, however, convinced that they are not glacial. I visited the locality in company with Professor Marshall with a view to seeing this line of hills and of examining the sections exposed near Henley and in the gorge of the Taieri River which cuts through the supposed moraine. The material is almost, if not entirely, composed of schist; in places it is clearly current-bedded and sometimes very hard and compact. Masses of a very big size do not seem to occur. Professor Park says that pieces over 12 feet are exceptional, but the largest I saw were much smaller than that. He also adds that no striated boulders occur in it, and certainly I saw none.

I was struck with the dissimilarity of this deposit to any glacial moraine I had ever seen. Both this and the gold-bearing deposit of Blue Spur near Lawrence in Otago are deposits of post-Jurassic age and rest unconformably on the underlying mica-schist, but whether they are associated with the late Cretaceous or with the Tertiary periods of deposition must await further investigation.

New Zealand geologists should be able to trace these schistose conglomerates in some definite association with undoubted Cretaceous or Tertiary deposits which should settle the question. Sir James Hector and A. McKay associated the Taieri deposits with the brown-coal series of supposed early Tertiary age.

There is evidence that the Henley or Taieri conglomerate mass is faulted parallel to the Taieri basin, but the fault is nowhere seen. The material at Blue Spur is certainly faulted, and the faults are clearly revealed by the gold-sluicing operations. There are certainly recent fault dislocations in New Zealand, but those at Blue Spur appear to be of much earlier date than Pleistocene.

The removal of these schistose faulted conglomerates of Eastern Otago from the domain of glacial action removes also the chief evidence for any pre-Pleistocene glaciation. The traces of the Alpine glaciation are so fresh that any question of their being of Pliocene age is excluded.

Finally, as against the ice-sheet theory it may be mentioned that the two masses of Tertiary volcanic rocks of the Otago and Banks Peninsula on the east coast occupy a similar position relatively to

the Alpine chain as the Cleveland Hills do to the centres of ice distribution in England or the Jura to the Swiss Alps. Had there ever been an ice-sheet in the South Island it must have extended at least to the foot of these elevated masses. Yet no trace of transported erratics is seen on the slopes of these hills nor on the plains between them and the Alpine range, nor have any glacial striæ been recorded on them.

Turning now to the Pleistocene glacial phenomena we find these splendidly developed along almost the whole length of the Alpine system of the South Island. The only place where I have had the opportunity of examining them at all closely is in the district of Lake Whakatipu. Here are all the features of a glaciation of the Alpine type splendidly displayed. There is the deep lake basin of Whakatipu, and how far this is due to the action of the ice affords the same opportunity for discussion as do the Swiss lakes. A fine arc-like terminal moraine spans the end of the lake at Kingston, having a length of 19 miles, and is cut through by the stream that drains the lake. At Bob's Cove, half-way up the lake, a fine series of erratics and striated surfaces is seen.

I came to the conclusion that there is no evidence of Pleistocene glaciation in the North Island, and that in the South Island the glaciation was of an Alpine and not of a regional type. The Pliocene and Pleistocene marine molluscan faunas show no evidence of the cold-water conditions such as occurs in countries that have experienced the conditions attendant upon the advance and retreat of an ice-sheet.

It remains for New Zealand geologists to determine whether there is in their Alps a succession of glacial deposits separated by inter-glacial episodes, or, as seems much more probable, that there was one glacial period whose deposits exhibit all the freshness shown by the remains of the Würm glaciation of the European Alps. Such seems to be the case with the glacial deposits I saw at Lake Whakatipu.

II.—The Base of the Chalk Zone of *Holaster planus* in the Isle of Wight.

By R. M. Brydone, F.G.S.

STARTING with the bed labelled "*Bicavea* bed" by Rowe,[1] the following generalized section represents the downward sequence in the Isle of Wight.

		Feet.
1.	*Bicavea* bed.	
	Seam of grey marl ("Grey Marl").	
2.	Hard rough nodular chalk	8–10
	Seam of dark marl ("Black Marl").	
3.	Very hard lumpy chalk, containing a layer of green-coated nodules and passing in its lower 2 feet or so into smooth white chalk veined with marl	12–15
	Seam of marl.	
4.	Firm smooth white chalk in massive courses separated by seams of marl.	

[1] *The Zones of the White Chalk of the English Coast*, pt. v, p. 220.

The "*Bicavea* bed" is universally accepted as part of the zone of *Holaster planus*. The smooth white chalk in massive courses is the typical chalk of the zone of *Terebratulina lata*. Where between them is the boundary between the two zones to be drawn?

[It will be convenient to have short names for the two beds numbered 2 and 3 above. *Membranipora Vectensis*, Bryd., is a striking form very characteristic of Bed 2, and it will be called the "*Vectensis* bed". Bed 3 is described in all published sections as containing a layer of green-coated nodules, and I have therefore used these words; but in the Compton Bay section by far the most prominent layer is a continuous greenish-yellow stony layer, forming a sort of culminating point to the progressive hardening which has been going on both from above and below. The "layer of green-coated nodules" has been named by Rowe the "spurious Chalk Rock", and the bed will be called the "spurious Chalk Rock bed".]

For a long time before 1903 the "spurious Chalk Rock", or perhaps more accurately the "spurious Chalk Rock bed", was regarded as the direct equivalent of the Chalk Rock. Up to 1889 it figured as the top bed of the zone of *T. lata*, but in that year Strahan[1] included it in his "Upper Chalk", and so impliedly, if not directly, in the zone of *H. planus*.

In 1903 Jukes-Browne[2] drew the boundary between these zones at the "Grey Marl" on the grounds that *Holaster planus* and *Micraster Leskei* do not become abundant until we get above it, and that it was uncertain whether any specimen or fragment of *Micraster* had up to then been found below it. In 1908 these arguments were almost annihilated by Rowe, who recorded that *Holaster planus* was as common below the "Grey Marl" as above it, and that *Micraster* in the shape of *M. cor-bovis* was by no means rare below it—observations which entirely accord with my own. He transformed the observation about *Micraster Leskei* by the statement that it did not occur at all until above the "*Bicavea* bed", but he, too, adopted the conclusion that the base of the zone of *Holaster planus* was the "Grey Marl" on the grounds that *Echinocorys scutatus*, *Micraster Leskei*, and *Micraster præcursor* do not occur below it.[3] I have no reason to dispute these statements, but their force as arguments in the above connexion is quite another matter. On p. 221 we find that neither did *M. Leskei* or *M. præcursor* occur in the first bed *above* the "Grey Marl" (i.e. the "*Bicavea* bed"), and only one specimen of *E. scutatus* was found there. Now the "*Bicavea* bed" is unique in its quality of breaking up into blocks, which, owing to the presence of a marl seam both above it and below it, contain no element of any other bed, and whose horizon can be exactly determined owing to the ubiquity in it of *Bicavea rotula*. The result is that the surface of this bed which is available for study under the most favourable conditions is only limited by the number of blocks of it lying above wavewash on the falls of Culver Cliff and in Compton Bay, and its total area must be estimated in thousands of square

[1] *The Geology of the Isle of Wight* (Mem. Geol. Surv.), 1889.
[2] *The Cretaceous Rocks of Britain* (Mem. Geol. Surv.), pt. iii, 1904.
[3] Op. cit., p. 220.

yards. Under these circumstances the finding of a single specimen of *E. scutatus* is devoid of any serious significance, and when it figures as the sole reason for making a separation, not merely in zone but in stage, between the "*Bicavea* bed" and the "*Vectensis* bed", it is obviously so inadequate that it would be outweighed by the slenderest grounds for uniting these beds zonally. We are naturally led to ask whether there are any such grounds.

Accurate collecting from the "*Vectensis* bed" can only be carried on over the very limited area, probably not as much as 100 square yards all told, exposed *in situ*, as there is no outstanding feature by which fallen blocks from this bed can be certainly identified with it. I have only examined it once at Culver Cliff and twice at Compton Bay, but I have obtained from it besides other fossils the following significant ones:—

Holaster planus (abundant).
Pentacrinus (large ossicles in abundance).
Bourgueticrinus (joints in great abundance, many long and slender).
Lophidiaster ornatus (ossicles in abundance).
Crania Egnabergensis (several).
Lima Wintonensis (several).
Scalpellum maximum.
Polyzoa of twelve genera, most of which are represented by more than one species, including *Membranipora Vectensis* and *Bicavea rotula*.

Every item in this list is a strong link with the zone of *Holaster planus* and a strong distinction from the typical chalk of the zone of *T. lata* in the Isle of Wight at any rate. They must, of course, be taken quite strictly. A solitary specimen of *Lima Wintonensis* or *Crania Egnabergensis* would be unexpected without being startling in the typical *T. lata*-chalk of the Isle of Wight, but several specimens of either would compel a reconstruction of our ideas about that chalk. They are regular constituents of the *H. planus*-fauna, as also (at Compton Bay only) is *Scalpellum maximum*. *Lophidiaster ornatus*, which is fairly abundant in the Albian, is also known from the Chalk zones of *H. subglobosus*, *T. lata*, *H. planus*, and *Micraster cor-testudinarium*, but while it is abundant and very widespread in the zone of *H. planus* it is quite scarce in the other zones. Ossicles of *Pentacrinus* (to use the familiar name for convenience, not in ignorance of Dr. Bather's correction) are not of course *per se* peculiar to the zone of *H. planus*. I have them from every zone of the White Chalk, but the zone of *H. planus* is the only one beside that of *B. mucronata* in which they are not both scarce and small. Those of the "*Vectensis* bed" are as abundant as those of the *H. planus*-chalk and range freely up to $\frac{3}{8}$ in. in diameter. Ossicles of *Bourgueticrinus* are not unknown in the typical *T. lata*-chalk of the Isle of Wight, but my experience is that they are scarce throughout and always short and stout in the upper part; in the lower part they may be long, but are never slender; those of the *H. planus*-zone agree absolutely with those of the "*Vectensis* bed". *Holaster planus* might occur in the typical *T. lata*-chalk of the Isle of Wight, but it would take a long time to find a second specimen, and an abundance of it is hardly imaginable. Finally, Polyzoa, numerous both in species and individuals, forbid any association of the "*Vectensis* bed"

with the typical *T. lata*-chalk of the Isle of Wight. The presence of *Bicavea rotula* (paralleled inland by a specimen recorded at Arreton by Rowe himself[1]) should alone be enough to deter anyone from keeping this bed out of the zone of *H. planus* in order to attach it to the zone of *T. lata*; and you might search the typical *T. lata*-chalk of the Isle of Wight or any other South English district I am acquainted with for days without finding a single specimen of any Polyzoon, while Polyzoa are of course thoroughly characteristic and abundant features of the Senonian. The combined effect of these points seems to make an overwhelming case for uniting the "*Vectensis* bed" with the Senonian zone of *Holaster planus* in preference to the Turonian zone of *Terebratulina lata*.

Once the Senonian character of the "*Vectensis* bed" has been established the position of the "spurious Chalk Rock bed" becomes an open question. The bed itself is so hard and the area of it exposed *in situ* so small that palæontology is not likely to give much help. Its peculiar physical characters, striking as they are, cannot be relied upon for identifying fallen blocks, as there is, at Culver Cliff at any rate, a very similar bed in the zone of *M. cor-testudinarium*. It is to be noted, however, that *H. planus* is recorded from it, which is at any rate some argument in the Isle of Wight for attaching it to the zone of that fossil, and I have two specimens from it of the Polyzoon *Onychocella Lamarcki*, which is no ordinary fossil of the *T. lata*-chalk. The lithological evidence is all in favour of the same course. There is the widest difference between this bed and the typical *T. lata*-chalk, while there is a considerable affinity between it and the nodular and hard *H. planus*-chalk above. I come, therefore, to the conclusion that the "*Vectensis* bed" and the "spurious Chalk Rock bed" should both be placed in the zone of *Holaster planus*, and that the boundary between that zone and the zone of *T. lata* in the Isle of Wight should be drawn at the violent change from a long period of very uniform conditions of deposit which would seem to be marked by the appearance of the "spurious Chalk Rock bed".

It will be obvious that this conclusion cannot leave Dorset unaffected. The Dorset coast sections embracing the base of the zone of *H. planus* are, with the exception of the hopeless section in Durdle Cove, singularly inconvenient for access and very limited in area at the best. But it seems quite clear, from my own observations and those of Rowe,[2] that all along the Dorset coast a substantial thickness of typical *T. lata*-chalk is followed by a sequence for all practical purposes identical with that of the Isle of Wight; and the objections to associating either the relatively very fossiliferous chalk above the "spurious Chalk Rock bed" or the "spurious Chalk Rock bed" itself with the alien chalk below are of the same character as in the Isle of Wight, and, considering the nature of the exposures, equally strong.

The palæontological and lithological evidence can obviously in the Isle of Wight and apparently in Dorset be harmonized by taking the presence of *Holaster planus* as the test of the beginning of the zone

[1] Op. cit., p. 263.
[2] Op. cit., pt. ii, 1901.

of that fossil. If it is to be found at all in the typical *T. lata*-chalk it is a most exceptional occurrence, while it is found in the first bed above the typical *T. lata*-chalk (the "spurious Chalk Rock bed") and occurs freely in the next (the "*Vectensis* bed"). *Micraster* is a broken reed for this purpose. Even Rowe includes in the zone of *H. planus* 8 feet of chalk (the "*Bicavea* bed") in which he recognizes the absence of his test Micrasters for that zone, *M. Leskei* and *M. cortestudinarium* (*præcursor* shape).

In conclusion I should like to point out that my statements as to the absence or rarity of certain fossils in the zone of *T. lata* in the Isle of Wight (or elsewhere) cannot be tested by reference to any lists which do, like those of Rowe & Jukes-Browne, or may, record the fossils of the "*Vectensis* bed" or corresponding beds under the zone of *T. lata*. I have, for my own part, relied on my general experience of typical *T. lata*-chalk in the South of England, supplemented by an examination made expressly for this purpose of the exposures at Compton Bay and Culver Cliff on occasions when they were in excellent condition.

III.—Morphological Studies on the Echinoidea Holectypoida and their Allies.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

III. Some variations in the Structure of the Apical System of *Holectypus*.

(PLATE XVI.)

1. Introduction.

STRUCTURAL variation, unless due to injury or disease, may be regarded as a sign of racial health. The plasticity that allows or encourages deviation from the normal is an indication that the race is still young and vigorous, and that the deadening and ultimately fatal phase of stereotyped "perfection" has not been reached. The younger the race the more variable are even vital structures. It may be surmised that the several stages of race-life can be classified by the quantity and quality of variability shown. Indeed, variation, however induced or employed, is the determining force of evolution. Variants must therefore be considered as tentative and experimental efforts whose direction is parallel, or coincident, with the trend of evolution of the group. They can be used as indices of phylogeny that afford evidence of the ancestry, and also of the posterity, of their own and related stocks.

The recent work of R. T. Jackson on the relative positions of the ocular and genital plates in the apical systems of many Regular Echinoids, has brought to light abundant and convincing proof that a species consists of a "norm" surrounded by a series of regressive (or arrested) and progressive variants.[1] It has also been shown

[1] See especially "Phylogeny of the Echini" and "Studies of Jamaica Echini".

conclusively that the actual position of the norm between the extremes of variation differs in separate localities, resulting in local "varieties" which might be expected to extend their divergence until a distinct series of "species" was differentiated. A sufficient compilation of records would make possible a fairly confident prediction as to the main characters of these future species.

In the study of palæontological material there is often an opportunity to make actual observation of the ancestry and descendants of a particular species, and so it becomes possible to correlate the variations of that species with the known trend of evolution in the group to which it belongs. Conversely, an analysis of the variations may give suggestive evidence of relationships. I have been able to examine a considerable number of specimens of the common Inferior Oolite form, *Holectypus hemisphæricus*, from two localities in South-Western England. The results, in so far as they depend upon the structure of the apical system, seem sufficiently striking to be worthy of record. It must be remembered, however, that these results are based upon a study of some scores of individuals, while Jackson's are derived from hundreds or even thousands. The percentage calculations would be liable to considerable change when made from larger numbers.

In 1912 I showed, in this Magazine (Dec. V, Vol. IX, p. 8), the extreme diversity of structure met with in the apical system of the Holectypoida. Within the limits of the order there exists a record of the various methods whereby the readjustments, consequent on the backward migration of the periproct, were effected. The phylogenetically recent date of this disorganization rendered the apical system peculiarly sensitive to variation, and it was only in the later members of the order, and in descended stocks, that any fixity of structure was attained. The Bathonian species of *Holectypus*, though far in advance of *Plesiechinus* (in the repair of the apical system), are sufficiently near in time to the presumably Liassic origin of the order to exhibit much instability of apical structure. It would be interesting to examine a large series of *H. depressus* (the Inferior Oolite contemporary of *H. hemisphæricus*), so that a comparison could be made in this matter between the two strikingly distinct species. If any Cotteswold collectors who have a series of *H. depressus* would enable me to examine their specimens, I should be very grateful for the opportunity. Large numbers from one horizon and locality are required for useful results.

2. *Holectypus hemisphæricus*.

This well-known species is extremely abundant in the upper part of the Inferior Oolite (particularly in the *schlœnbachi*-hemera) of Dorsetshire. Its distribution is peculiar. As Richardson has shown, it is scarce, and often absent, in the Cotteswold district, flourishing only to the south of the Mendip axis. Its place in the more northerly region is taken by the small *H. depressus*, which, in its turn, is excessively rare in the south. In many parts of Dorsetshire *H. hemisphæricus* and *Pygorhytis ringens* vie with one another in

abundance, and sometimes threaten the supremacy of the all-pervading *Terebratula* (*Sphæroidothyris*) "*sphæroidalis*".

The specimens of *H. hemisphæricus* are commonly small, averaging 2 cm. in diameter, and are remarkably uniform in size. It is easy, therefore, to collect plentiful material for a study of variation, without the complication of differences due to age. For the purposes of the present paper (which is only a preliminary note) specimens from two localities have been used, and no others are referred to, so as to avoid confusion. In a collection in the Manchester Museum there are twenty-two specimens (suitable for study) labelled "Broadwindsor"; all, apparently, from one quarry. In my own collection there were 167 specimens from a layer about one foot thick in a quarry on the side of the main road east of Bridport. Many of the latter series have been broken up or otherwise disposed of in the course of other work upon them, but examples of all observed types of variation have been retained.

Taking the 189 specimens together, the normal structure of the apical system (occurring in 55·5 per cent) is that represented by Pl. XVI, Fig. 2. But owing to the disparity in the numbers from the two localities, this combined percentage is misleading. The true relations of the "norms" and "variants" may be more satisfactorily expressed by means of the following table:—

Locality.	Total Number of Specimens.	Apical System as in				Aberrant Forms.	
		Pl. XVI, Fig. 1.		Pl. XVI, Fig. 2.			
		No.	%	No.	%	No.	%
Broadwindsor.	22	12	**55**	4	**18**	6	**27**
Bridport . .	167	32	**19**	101	**61**	34	**20**

From this table it appears that there are separate "norms" for the two localities, although the small number of the Broadwindsor specimens is unfortunate. Fifty-five per cent of the Broadwindsor forms have a type of apical system which is found in only 19 per cent of those from Bridport. And conversely 61 per cent of the Bridport examples possess a structure found in only 18 per cent of those from Broadwindsor. The percentage of aberrant types from both localities is surprisingly high.

(a) *The Broadwindsor norm.* (Pl. XVI, Fig. 1.)

The distinguishing character of this type of apical system depends upon the direction of the long axis of genital 2 (the madreporic plate). This axis is at an angle of between 80° and 75° to the antero-posterior axis of the test. The five genital plates are all subequal, but plate 1 is somewhat reduced. Owing to the direction of elongation of plate 2, plates 3 and 5 meet along a short transverse suture, so that plate 4 is not in contact with plate 2. The ocular plates are of considerable size, and are all approximately similar.

(b) *The Bridport norm.* (Pl. XVI, Fig. 2.)

Here the long axis of the madreporic genital is inclined at an angle of between 60° and 55° in relation to the antero-posterior axis. The genital plates are subequal, but plate 3 is somewhat reduced. Owing to the obliquely transverse extension of plate 2, plates 3 and 5 are widely separated from one another, and plate 4 meets plate 2 along a slightly curved suture of some length. The oculars are similar to those of the Broadwindsor type.

Among the twelve Broadwindsor specimens, and thirty-two Bridport specimens, that conform to Fig. 1, there are, of course, numerous trifling differences in the proportionate sizes of the plates and the angles of the sutures, but none of these differences affect the relation of the plates to one another. The same remark applies to the 4 and 101 specimens represented by Fig. 2. The two figures are copies of specimens that show the average characters for the respective types. Since the axis of the madreporic genital of *Plesiechinus* is almost parallel to the antero-posterior axis, and that of *Conulus* considerably inclined, the Bridport norm would seem to be progressive beyond the Broadwindsor type.

(c) *The aberrant forms.*

Beside the two alternative structures in the apical system above noted, there are three classes of variants that show more striking departures from the normal. These classes are illustrated by Pl. XVI, Figs. 3, 4, 5, and 6.

(1) *Variant* 1. (Pl. XVI, Fig. 3; cf. also Figs. 6, 7, and 8.)

This variation, which consists in the transgression of the madreporite on to genital 3, is by far the commonest type of abnormality in the series examined, and among other Holectypoids as well. Of the six aberrants from Broadwindsor five possess this character; one of them (Fig. 6) combining with it a different type of variation. Of the thirty-four aberrants from Bridport, no fewer than thirty-two possess a similar character. The five Broadwindsor specimens are all "norms" for their locality as regards the relations of the genital plates, but, as a comparison of Figs. 1 and 3 will show, the proportions of the plates are various. Thirty of the Bridport specimens have the "Bridport norm" in plate relations, the other two being like those from Broadwindsor.

I have not seen any specimens of *H. hemisphæricus* in which the madreporic perforations extend on to any other plate than genital 3. Variants of this character, often carried to a further degree, are by no means uncommon in *Conulus* (Pl. XVI, Fig. 8). In the specimen figured all four genital plates are perforated by the madreporite, but it is only on plate 3 (of the abnormal ones) that the pores are at all abundant.

In *Discoides* the extension of the madreporite on to all five genital plates is a generic character (Pl. XVI, Fig. 7). The variants of *Holectypus* of the type under consideration may then be considered to be progressive in the *Discoides* direction, while the similar variants

in *Conulus* might be called "parallel variants", on the supposition that there is no direct phyletic sequence between *Conulus* and *Discoides*.

(2) *Variant* 2. (Pl. XVI, Figs. 4 and 5; cf. also Figs. 6 and 9.)

One specimen from Broadwindsor (Fig. 5) and two from Bridport (Fig. 4) show the development of a supernumerary plate more or less midway between genitals 2 and 5. In both the Bridport forms this is small and pentagonal, having sutural connexion with all the genitals except plate 4. (Both specimens have the "Broadwindsor" arrangement of the genital plates.) In the Broadwindsor specimen the supernumerary is large and hexagonal, and, being in contact with all five genitals, acts as a kind of "centrale". There is no evidence to prove that this included plate is not really genital 5, while the plate in the posterior region is the additional one; but it seems more reasonable to suppose that the appearances are not deceptive, and that the internal plate is actually the supernumerary.

Additional internal plates within the true cycles of the apical system occur in the Calycina among Regular, and in some of the *Clypeus–Nucleolites* series of the Irregular, Echinoids. This distribution of supernumeraries opens up an interesting speculation when applied to the variants under notice. *Acrosalenia* is an ancient, and in most respects, primitive member of the Diademoida (Centrechinoida), and may well have originated collaterally with the Holectypoids in Liassic times, even if it is not on their line of descent. So that a comparison of the aberrant *Holectypus* with *Acrosalenia* would class the variation in the former as either arrested (or regressive) or perhaps "arrested parallel". In the case of "*Nucleolites*" (as illustrated by "*N.*" *orbicularis* (Pl. XVI, Fig. 9), a considerable number of more or less symmetrically placed supernumeraries occurs posteriorly to the large madreporic genital. In Fig. 9, as I interpret it, plate *c* (the most posterior) represents genital 5, and either *b* or *a* might be correlated with the additional plate in *Holectypus*. In view of the fairly certain primitiveness of *Holectypus*, and the equally probable lack of direct sequence from that genus to the Nucleolitidæ, a comparison of the two would class the variant as an imperfectly "progressive parallel". This comparison will appear less far-fetched when the next section has been read.

(3) *Variant* 3. (Pl. XVI, Fig. 6; cf. also Figs. 8 and 9.)

This solitary specimen from Broadwindsor shows a very striking abnormality. In the first place, it possesses the characters of variant 1, in that the madreporite is partly situated on genital 3. There is a "centrale"-like, hexagonal, imperforate plate a little behind the centre of the system, approximately similar in area to the two genitals (1 and 4) that flank it. Behind this included plate the two posterior oculars (I and V) meet. Both are enlarged and distorted in shape, but plate 1 is by far the larger of the two. There is thus no posterior genital (5); at least, as concerns the margin of the system. At first I was of the opinion that the included hexagonal plate was actually the fifth genital shifted anteriorly. But in view of

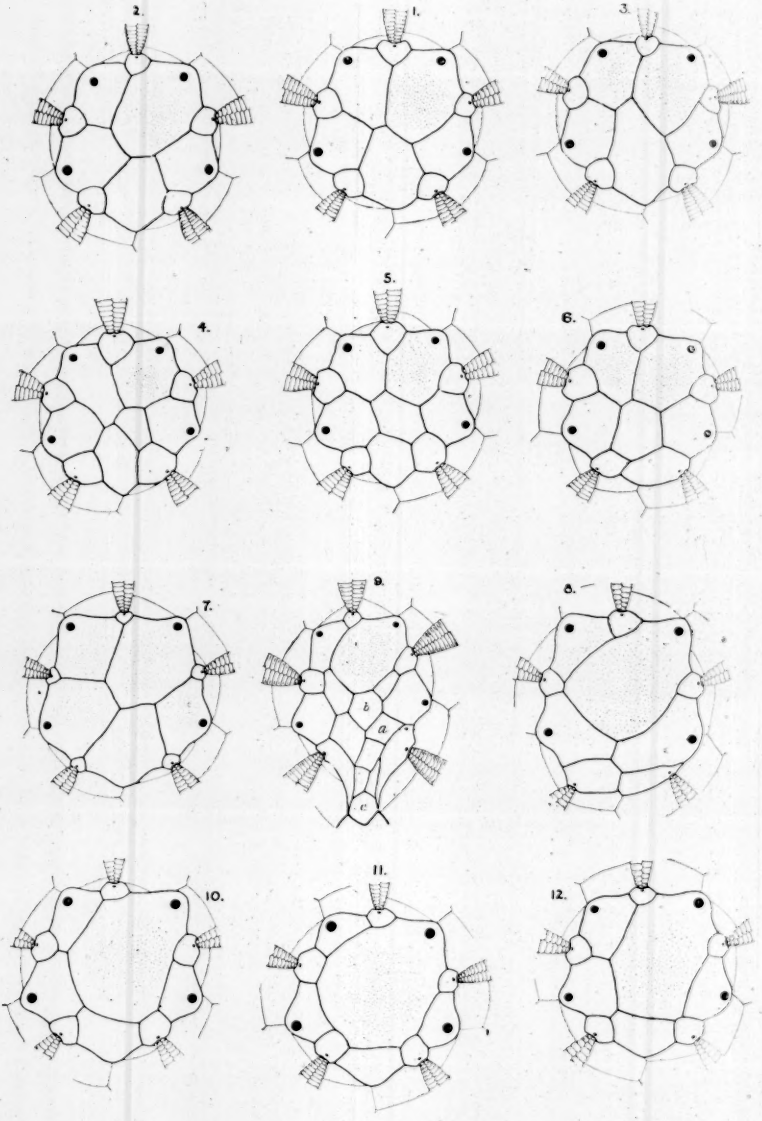
the structures observed in variant 2, I now incline to the belief that the included plate is a supernumerary, and that genital 5 is wanting. If this is a correct interpretation of the specimen, it would prove to be similar to variant 2 in this respect as compared with *Acrosalenia* or "*Nucleolites*". On comparing oculars I and V in Figs. 6 and 9, a certain resemblance in their distorted shape and increased length is seen. In this respect also the *Holectypus* variant can be considered as "progressively parallel" to the "*Nucleolites*" norm.

A comparison between Figs. 6 and 8 (*Conulus*) is perhaps more satisfactory. The generic character of the *Conulus* apical system is the absence of the fifth genital and the consequent meeting of the posterior oculars, I and V. It is seen that in both figures these oculars are much enlarged. Although in the *Holectypus*, ocular I is the larger of the two, while the reverse is the case in the *Conulus*, the discrepancy is more apparent than real. Other specimens of *Conulus* (both *C. subrotundus* and *C. albogalerus*) have ocular I larger than ocular V. The less usual type was chosen for figuring because of its possession of the characters of variant 1. It will be readily seen that if the supernumerary plate in the *Holectypus* were removed the consequent readjustments would bring genitals 1 and 4 into contact (as they are in *Conulus*); and a very slight alteration in the dimensions of genital 2 would produce an almost exact similarity between the two systems. When it is realized that in *Holectypus depressus* (see Fig. 11) genital 2 may be in contact with ocular IV (as is the case in *Conulus*), the correspondence between the two structures becomes more obvious.

Thus while the included supernumerary plate and the posterior oculars (in the variant illustrated in Fig. 6) show an inclination towards the *Nucleolites* character, the absence of genital 5 and the meeting of oculars I and V indicate a very definite "progressive" variation towards *Conulus*. Whatever may be the ancestry of the last-named genus, its line of descent cannot have been remote from that of *Holectypus*.

3. *Holectypus depressus* (Cornbrash). (Pl. XVI, Figs. 10 and 11.)

Although I have not enough specimens of this large and abundant species (which is surely specifically distinct from the small Inferior Oolite form of the same name), there are two types of apical system shown in the few examples at my disposal. The madreporic genital (2) is always large in this species, and the madreporite occupies a prominent position in the centre of the system. In six specimens, ranging in diameter from 2 to 5 cm., the plates are arranged as in Fig. 10. Using a terminology analogous to that employed by Jackson for Regular Echinoids, this type may be said to have oculars I, II, and III "insert" (to the madreporite instead of to the periproct), and oculars IV and V "exsert". (By a similar argument *H. hemisphæricus* has only oculars II and III "insert".) But in one medium-sized specimen (Fig. 11), with a diameter of about 3–5 cm., genital 2 is so enormously expanded that the remaining genitals are much reduced in size, and all five oculars are "insert", being in contact with the madreporic plate. The specimens are



H. L. H., del.

NORMAL AND ABNORMAL APICAL SYSTEMS OF *HOLECTYPUS* AND OTHER GENERA.

all from the same locality, and those of the remaining six that approximate to the size of this specimen have the characters of Fig. 10. So there are indications that another series of variants could be traced in this species. The original of Fig. 11 cannot be regarded as progressive towards the Corallian species (*H. oblongus*, Fig. 12), for in six specimens of that form, from Upware, the ocular "insertion" is identical with that of the Cornbrash "norm". The contact between genital 2 and ocular IV in this specimen suggests comparison with the conditions in the apical system of *Conulus* (Fig. 8), but that feature, and the large size of the madreporic genital (not a variant character) are the only points of resemblance between the two.

4. Summary.

The characters of the apical system of a series of *Holectypus hemisphæricus* from the same horizon at two localities in Dorsetshire are analysed and described. It is found that the average relations of the plates of the system are different at the two localities, although certain numbers of identical forms occur at both. Out of 189 specimens (from both localities), 40 show serious departures from the normal type. These abnormalities are of three classes. One, the most prevalent, consists in the presence of madreporic pores on genital 3, in addition to the normal perforation of genital 2. This is regarded as a "progressive variant" in the direction of *Discoides*. The second, occurring in three specimens, consists in the interpolation of a supernumerary plate within the system. It is suggested that this may be either a "regressive variant" towards *Acrosalenia*, or a "progressive variant" towards *Nucleolites* (as illustrated by *N. orbicularis*). In neither case would this variation coincide with actual phyletic sequence, so that it is styled "parallel variation". The third type of variant, seen in one specimen only, combines both the first and second types, and in addition shows an absence of genital 5 and a corresponding increase in the size of the posterior oculars, which meet round the back of the system. The variation in this specimen is interpreted as being "progressive" towards *Discoides*, "parallel progressive" or "regressive" towards *Nucleolites* or *Acrosalenia* respectively, and "progressive" towards *Conulus*. There are indications of a different series of variants in the *Holectypus depressus* from the Cornbrash. The high percentage of variation in the composition of the apical system of *Holectypus* is regarded as an indication of the evolutional activity of the genus, and of its near approximation in time and phylogeny to the common origin of many of the groups of Irregular Echinoids.

EXPLANATION OF PLATE XVI.

All figures are considerably magnified, and are brought to a uniform size for convenience of comparison. All are viewed from the outside of the test, so that the numbering of the plates is in an anti-clockwise direction.

FIG.

1. *Holectypus hemisphæricus.* Broadwindsor. The normal apical system for this locality. Genitals 3 and 5 in contact.
2. ,, ,, Bridport. The normal apical system for this locality. Genitals 3 and 5 separated by 2.

Fig.		
3.	*Holectypus hemisphæricus.*	Broadwindsor. Variant 1.
4.	,, ,,	Bridport. Variant 2.
5.	,, ,,	Broadwindsor. Variant 2.
6.	,, ,,	Broadwindsor. Variant 3.
7.	*Discoides cylindricus.*	Wallingford. Normal apical system.
8.	*Conulus subrotundus.*	Reigate. Cf. variant 1.
9.	*Nucleolites orbicularis.*	Rushden. ? Normal apical system.
10.	*Holectypus depressus.*	Rushden. Oculars I, II, and III "insert".
11.	,, ,,	Same locality. All oculars "insert".
12.	,, *oblongus.*	Upware. Normal apical system.

IV.—On some new Cenomanian and Turonian Cheilostome Polyzoa.

By W. D. Lang, M.A.

(By permission of the Trustees of the British Museum.)

(PLATE XVII.)

Hapsidopora, new genus.

(ἡ ἁψίς, 'an arch,' in reference to the hoop formed proximally to the aperture.)

Diagnosis.—Asty incrusting, uniserial, with bilateral and unilateral branching; œcia dimorphic; normal œcia with short caudæ or without caudæ; pyriform; termen a complete, high, narrow, oval ridge with few small spines on its circumference and, at the proximal-lateral corners of the aperture, a pair of stout spines which sometimes, if not always, bend towards one another and fuse in the middle line; apparently there are no spines around the distal end of the aperture; extra-terminal front-wall well-developed proximally, and arched; intra-terminal front-wall a wide, depressed lamina; aperture oval, sub-quadrate, somewhat constricted laterally; avicularia small, one, or a pair, placed laterally and somewhat distally with regard to each aperture, rather abruptly pointed with the distal ends curved towards the aperture they encompass; ovicells hyperstomial.

Genotype.—*Hapsidopora arcuata*, n.sp.

Remarks.—It is noteworthy that the terminal ring of *Hapsidopora* is complete proximally, and not smoothed away as in so many other forms with a wide lamina.

Key to the genus *Hapsidopora*.

A. Pair of spines at the proximal-lateral corners of aperture not so stout, and the terminal spines proximal to these larger than in *H. arcuata*	1. *H. harmeri.*
B. Pair of spines at the proximal-lateral corners of the aperture very stout and arching over, fuse with one another in the mid-line; terminal spines proximal to these smaller than in *H. harmeri*	2. *H. arcuata.*

HAPSIDOPORA HARMERI, n.sp. Pl. XVII, figs. 1 and 2.

(As a mark of respect to my colleague and former teacher, Dr. S. F. Harmer.)

Diagnosis.—*Hapsidopora* with comparatively large terminal spines, and the spines in the proximal-lateral corners of the aperture smaller than in *H. arcuata*; the terminal ring makes a narrower ellipse; the avicularia are slightly slenderer than in *H. arcuata*.

Type-specimen.—British Museum specimen no. D. 21673; Cenomanian, Chalk Marl, 20 ft. from the base; Cambridge; F. Möckler Coll.

HAPSIDOPORA ARCUATA, n.sp. Pl. XVII, figs. 3 and 4.

(*Arcuatus*, 'arched,' in reference to the hoop-like structure proximal to the aperture.)

Diagnosis.—*Hapsidopora* with very small terminal spines and a very stout pair of spines at the proximal-lateral corners of the aperture; the terminal ring makes a wider ellipse; the avicularia are somewhat stouter than in *H. harmeri*.

Type-specimen.—British Museum specimen no. D. 22871; Cenomanian, Chalk Marl, 20 ft. from base; Cambridge; F. Möckler Coll.

TYLOPORA, new genus.

(ὁ τύλος, 'a knob,' in reference to the beaded termen.)

Diagnosis.—Asty incrusting, pauciserial and branched; at each branch an uniserial stage is nearly or quite resumed, though sometimes a lateral bud from an œcium of one branch curves away and joins the other branch; œcia dimorphic, with unilateral budding, elliptical with tapering proximal ends, but no caudæ; termen plain or with minute spines, to beaded; extra-terminal front-wall present only at the extreme proximal end of the œcium; intra-terminal front-wall a wide, depressed, proximal lamina prolonged on each side in lateral terminal bevels; aperture circular to oval; renewed œcia abundant; avicularia small, blunt, generally one, sometimes a pair placed distally and somewhat laterally to each œcium.

Genotype.—*Tylopora lorea*, n.sp.

Key to the genus *Tylopora*.

A. Termen plain, or with minute spines . . . *T. ligatrix.*
B. Termen beaded.
  1. Œcia shorter (about ·6 mm) and blunter distally . . . . . *T. rowei.*
  2. Œcia longer (about ·8 mm) and more pointed distally . . . . . *T. lorea.*

TYLOPORA LIGATRIX, n.sp. Pl. XVII, figs. 5 and 6.

(*Ligator*, 'a binder,' invented from *ligare* 'to bind', from the strap-shaped asty.)

Diagnosis.—*Tylopora* with a plain termen, or, if spines are present, these are exceedingly small.

Type-specimen.—British Museum specimen no. D. 29205; incrusting *Conulus subrotundus* Leske. [Turonian, zone of *R. cuvieri*]; Burham, north-west of Maidstone, Kent. Coll. Hon. R. Marsham.

Tylopora rowei, n.sp. Pl. XVII, figs. 7 and 8.

(As a mark of regard to Dr. A. W. Rowe, who kindly lent me the type-specimen for description.)

Diagnosis.—*Tylopora* with a beaded termen, and short (about ·6 mm. long) rather blunt œcia.

Type-specimen.—In the collection of Dr. Rowe of Margate; incrusting *Infulaster excentricus* (S. Woodward); Turonian, zone of *Terebratulina*; Norfolk.

Tylopora lorea, n sp. Pl. XVII, figs. 9, 10 and 11.

(*Loreus*, 'made of thongs,' in allusion to the strap-shaped asty.)

Diagnosis.—*Tylopora* with a beaded termen, and longer (about ·8 mm.) and rather more pointed œcia.

Type-specimen.—British Museum specimen no. D. 15389; Turonian, zone of *Holaster planus*; Church Top Pit, South Elkington, west of Louth, Lincs; Coll. C. S. Carter.

EXPLANATION OF PLATE XVII.

Fig.

1. *Hapsidopora harmeri*, n.sp. Portion of the type-specimen, showing bilateral and unilateral branching. × about 34 diameters. British Museum specimen no. D. 21673. Cenomanian, Chalk Marl. Cambridge. F. Möckler Collection.
2. *Hapsidopora harmeri*, n.sp. A single œcium—the distal-most—of the part of the type-specimen represented in fig. 1. × about 50 diameters.
3. *Hapsidopora arcuata*, n.sp. Portion of the type-specimen, showing bilateral and unilateral branching. The most proximal œcium is a renewed œcium. × about 26 diameters. British Museum specimen no. D. 22871. Cenomanian, Chalk Marl. Cambridge. F. Möckler Collection.
4. *Hapsidopora arcuata*, n.sp. A single œcium from another part of the type-specimen than that represented in fig. 3. × about 40 diameters.
5. *Tylopora ligatrix*, n.sp. Portion of the type-specimen. × about 26 diameters. British Museum specimen no. D. 29205. [Turonian, zone of *Rhynchonella cuvieri*.] Burham, Kent. Hon. R. Marsham Collection.
6. *Tylopora ligatrix*, n.sp. A single œcium—the most distal on the right-hand side—of the part of the type-specimen represented in fig. 5. × about 40 diameters.
7. *Tylopora rowei*, n.sp. Portion of the type-specimen. × about 26 diameters. Turonian, zone of *Terebratulina*. Norfolk. In the collection of Dr. A. W. Rowe.
8. *Tylopora rowei*, n.sp. A single œcium—the most distal on the right-hand side—of the part of the type-specimen represented in fig. 7. × about 40 diameters.
9. *Tylopora lorea*, n.sp. Portion of the type-specimen, showing a branch. Five of the œcia are renewed œcia, and four are closed œcia; the remaining œcium (on the left, proximally) is normal. × about 26 diameters. British Museum specimen no. D. 15389; Turonian, zone of *Holaster planus*. South Elkington, Lincs. C. S. Carter Collection.
10. *Tylopora lorea*, n.sp. A single œcium, the only normal one in the portion of the type-specimen represented in fig. 9, namely that on the left-hand side and proximally situated. × about 40 diameters.
11. *Tylopora lorea*, n.sp. A single renewed œcium—just proximal to the middle—of the part of the type-specimen represented in fig. 9. × about 40 diameters.

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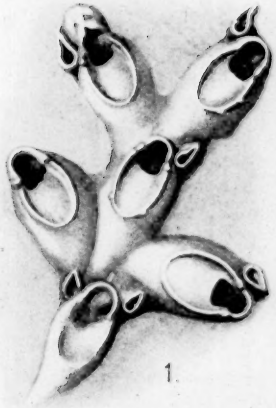
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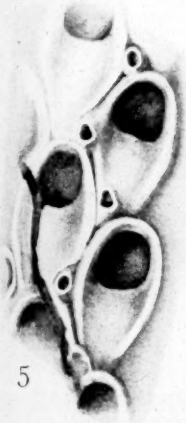
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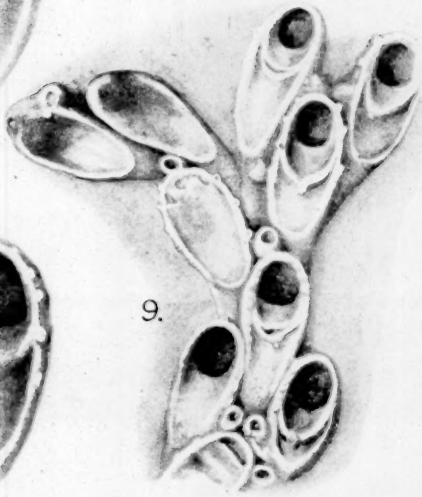
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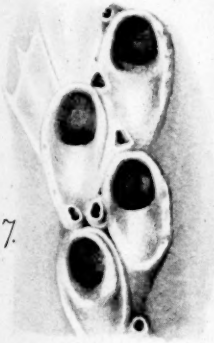
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G. M. Woodward, del.

HAPSIDOPORA and TYLOPORA.

NOTICES OF MEMOIRS.

I.—The Conchological Features of the Lenham Sandstones of Kent, and their stratigraphical importance.[1] By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

Part I.

AT various points along the summit of the chalk escarpment forming the North Downs of Kent and Surrey and extending from Paddlesworth near Folkestone to Lenham near Maidstone, and thence to Netley Heath between Guildford and Dorking—a distance east and west of about seventy miles—there occur in pockets, cavities, or "pipes" of the Chalk formation, certain scattered masses of a reddish ferruginous sandstone at considerable altitudes above sea-level; at Paddlesworth this sandstone has been observed at 600 feet; at Lenham 680 feet; while at Netley Heath it is found at a height of between 570 and 600 feet. Sandstones of corresponding age are met with in France particularly on the hills between Calais and Boulogne, and on Cassel Hill near Dunkirk at 515 feet; they also occur at Louvain (200 feet) and Diest, both in Belgium, the beds of the latter locality having yielded fossiliferous remains bearing a resemblance to the Lenham fauna, although often differing in specific characters.

The more important of these sandstone deposits, so far as this country is concerned, are those found on the Lenham Downs, as they contain the remains of a marine fauna, chiefly of conchological interest, whereas the beds of other districts are generally unfossiliferous, although it should be mentioned that a few Mollusca of rather uncertain character have been obtained from both Paddlesworth and Netley Heath.

The fossils known in the various museum collections have been mostly obtained from a large disused chalk quarry situated about half a mile to the north of Lenham, of which an excellent sketch may be consulted in Mr. Reid's "Pliocene" memoir of 1890, showing the vertical positions assumed by the fossiliferous sandstone pipes seen in the limestone exposure. It has been generally recognized that such deposits represent the remnants of a marine Tertiary formation belonging to early Pliocene times, although my own investigations have led to somewhat different results, and I am more inclined to refer them to the latest division of the Miocene period.

The organisms occur as casts and cavities in the sandstone, and are frequently in a fragmentary condition, rendering their determination extremely difficult. The walls of the cavities, however, often retain sculpture characters, so that it is possible by the aid of wax impressions to obtain reliable evidence as to external details which

[1] We have just received in a connected form the complete text of Mr. R. B. Newton's valuable memoir "On the Conchological Features of the Lenham Sandstones of Kent, and their stratigraphical importance". This paper formed the subject of his Presidential Address to the Conchological Society of Great Britain and Ireland at Manchester, on October 16, 1915, and was afterwards printed in four parts in the *Journal of Conchology*, vol. xv, 1916–17, making 64 pages, with 4 plates of Mollusca. With the author's kind permission we give an abridged notice.

may be safely used for purposes of identification. To Mr. Clement Reid, F.R.S., we are mainly indebted for most of our later knowledge of the Lenham fauna, his researches forming part of the "Pliocene" memoir before mentioned. At that time Mr. Reid had obtained an important series of fossils from the Lenham Beds for the Museum of Practical Geology, which, after being determined, were systematically referred to in the memoir. In order to facilitate my studies on this subject and to enable me to determine certain collections of similar fossils in the British Museum, especially that formed by Mr. Graham Wallas, I was very kindly allowed to loan this valuable type collection made by Mr. Reid. During my studies in this direction it has been necessary to introduce a certain amount of revision, both among the genera and species as laid down in Mr. Reid's memoir. The larger amount of material available at the present time has also resulted in the determination of additional species, so that the shells are regarded as numbering 77 species, which include 1 Scaphopod, 32 Gastropods, 43 Pelecypods, and 1 Brachiopod, whereas Mr. Reid's conchological list embraced 65 species, consisting of 1 Scaphopod, 27 Gastropods, 36 Pelecypods, and 1 Brachiopod. Among the 32 Gastropods now recognized, a new species has been described under the designation of *Ringiculella lenhamensis*. In view of the fact that no figures have yet been published of Lenham fossils, I have had prepared some photographs of the more important shell-remains, which on account of their reddish-brown colour and their more or less obscure character have not been particularly successful; yet it is hoped they may serve a useful purpose in stimulating the interest of the student who desires to pursue further researches on the conchology of these little-known beds.

To complete the Lenham fauna I have here briefly introduced a list of the other organic remains which are found associated with the shells:—

PISCES.

Selachian vertebræ and a palatal plate as determined by Dr. A. S. Woodward. Coll. B.M.[1] (Graham Wallas).

POLYZOA.

Fascicularia aurantium, M. Edwards. Coll. M.P.G., No. 398.

Cupularia canariensis, Busk. Coll. M.P.G., No. 399. B.M. (Graham Wallas).

ANNELIDA.

Ditrupa subulata, Deshayes, sp. Coll. M.P.G., No. 395.

CRUSTACEA.

[A decapod claw.] Coll. B.M. (Graham Wallas).

Balanus. Coll. M.P.G., No. 396.

ECHINODERMATA.

Temnechinus (?). Coll. B.M. (Graham Wallas).

Echinus woodwardi, Desor. Coll. M.P.G., No. 394. B.M. (Prestwich and Graham Wallas).

Dorocidaris papillata, Leske, sp. Coll. B.M. (Prestwich).

ACTINOZOA.

Trochocyathus (?). Coll. B.M. (Graham Wallas).

[1] The author desires to acknowledge his thanks to the authorities of the Museum of Practical Geology, and particularly to Mr. H. A. Allen, F.G.S., of that institution, for allowing him access to the "Reid" Collection. The letters B.M. and M.P.G. throughout this work apply respectively to the British Museum and the Museum of Practical Geology.

In addition to these organisms the Lenham sandstones occasionally exhibit impressions of the spines of *Cidaris clavigera*, König, and remains of *Inoceramus*-shell associated with the sponge *Cliona*, all of which belong to the Chalk (Senonian) formation, and are consequently of derivative origin. No trace has been discovered in these beds of any fossils which could possibly have been derived from Eocene rocks.

Bibliography (1857–1915).[1]

The history of the Lenham deposits and their fauna was commenced by the late Sir Joseph Prestwich in 1857,[2] when reporting the discovery by W. Harris and Rupert Jones of certain "blocks of gritty ferruginous sandstone, full of casts of shells", in some sand-pipes in the Chalk at Lenham, eight miles east of Maidstone, which they regarded as belonging to the basement-bed of the London Clay. Prestwich was familiar with similar sandstones occurring at Paddlesworth, near Folkestone, at a height of about 600 feet above sea-level, and at Vigo Hill near Otford in Kent, mentioning likewise that they were to be found in scattered fragments along the summit of the North Downs, extending from near Folkestone to Dorking in Surrey; but from the fossils he considered that the sandstones were of Lower Crag age, on account of the presence of a *Terebratula* resembling *T. grandis*, several species of *Astarte*, and a large *Lutraria*-like shell; this view being also shared by Searles Wood, who had examined the fossil remains, and recognized the importance of the occurrence of a *Pyrula* and an *Emarginula* as supporting that horizon. Prestwich also noted that beds of similar structure were present on the hills between Calais and Boulogne, at Cassel Hill near Dunkirk, and at Louvain and Diest in Belgium, besides thinking it possible that such sandstones were connected with the Carentan beds of Normandy.

In the following year Prestwich[3] again returned to the subject, aided by Searles Wood. He noticed that many of the species found at Lenham were of southern origin, thus confirming his previous ideas that the deposits were of Lower or Coralline Crag age. His determinations of the shells included the following forms:—

Scaphopoda.
Dentalium costata (?).

Gastropoda.
Emarginula reticulata (?).
Nassa prismatica (?).
Scalaria subulata (?).
Pyrula.
Trochus.
Natica.
Rissoa (?).
Phorus, related to *Trochus cumularis*, Brong.

[1] The conchological determinations mentioned in the following memoirs are those of the authors themselves, without any attempt at a rectification of the nomenclature.

[2] "On some Fossiliferous Ironstone occurring on the North Downs": Quart. Journ. Geol. Soc., vol. xiii, pp. 212, 213, 1857.

[3] "On the Age of some Sands and Iron-Sandstones on the North Downs"; with a Note on the Fossils, by S. V. Wood: Quart. Journ. Geol. Soc., vol. xiv, pp. 322–35, 1858.

PELECYPODA.

Arca lactea (?).
Pecten avicula (?) and *P. bruei*.
Modiola modiola (?).
Pectunculus glycymeris (?).
Nucula nucleus (?).
N. depressa, Nyst.
Leda lanceolata and *L. myalis* (?).
Astarte digitaria, *A. pygmæa*, *A. compressa* (?), *A. omalii* (?).
Cardium (with spines) and *C. edule*.
Cytherea rudis (?).
Tapes perovalis.
Lutraria elliptica.
Crassatella concentrica (?), Duj.
Tellina donacina (?) or *Donax*.
Mactra triangulata (?).
Cardita, *Lucina* or *Diplodonta*, *Kellia* or *Lepton*, *Isocardia*.
Venus (?), *Anatina*, *Panopœa* (?).

BRACHIOPODA.

Terebratula grandis (?).

In the same memoir Prestwich referred to the occurrence of similar ferruginous sandstones to those at Lenham on the chalk downs between Calais and Boulogne, and at Cassel Hill in French Flanders, 515 feet above the sea, overlying the Calcaire Grossier series. It was mentioned that such beds, although without fossils, had been determined by Dumont and Lyell as equivalent to the Diestian Sands of Belgium, which they classed with the English Crag, because the same sands had been found at Louvain overlying the Limburg and Bolderberg strata, containing impressions of shells of *Terebratula grandis*, *Solen ensis*, and *Syndosmya prismatica*, besides thirteen genera of indeterminable species. In a further reference to the Lenham Mollusca, Searles Wood [1] mentioned that the *Pyrula* and *Pectunculus* resembled certain sandstone casts from the Red Crag (Box-stone specimens), although a closer determination was not possible from their peculiar preservation.

Lyell [2] recognized the Lenham Beds as of Upper Miocene or Falunian age, and similar to the Diestian Sands of Belgium, and, moreover, probably older than the Coralline Crag.

He had traced the Diestian beds, which "abound in green grains", from Diest by Louvain and Oudenarde to Cassel in French Flanders and capping the hills of those places—away to the English Downs near Folkestone, and appearing at such places as Paddlesworth, Lenham near Maidstone, etc. He referred to the occurrence in those beds of *Terebratula grandis*, casts of *Astarte*, *Pyrula*, *Emarginula*, which were all common to the British Crag, the first-named being specially characteristic of the Belgian Diestian.

As a result of an examination of the Prestwich Collection and that of the Geological Survey, Von Koenen [3] was of opinion that Lyell was wrong in his estimate of a Miocene age for the iron-sandstones of Kent, he regarding them as Pliocene because he considered they contained characteristic shells of the Upper Crag.

Mr. Whitaker [4] next gave his opinion on the age of the Lenham fauna, assisted by Gwyn Jeffreys in connexion with the molluscan

[1] "On the Extraneous Fossils of the Red Crag": Quart. Journ. Geol. Soc., vol. xv, pp. 32–45, 1859.

[2] *Elements of Geology*, 6th ed., pp. 233, 368, 1865.

[3] "Die Fauna der Unter-oligocänen Tertiärschichten von Helmstadt bei Braunschweig": Zeitsch. Deutsch. Geol. Ges., vol. xvii, p. 461, 1865.

[4] "On the Lower London Tertiaries of Kent": Quart. Journ. Geol. Soc., vol. xxii, p. 430, 1866.

determinations. Their results suggested an Eocene horizon, because among the fossils was identified a *Phorus* like *P. agglutinans, Cyrena cuneiformis*, and a small *Nucula* like *N. minor*.

Bristow [1] supported the Eocene age theory for the Paddlesworth ferruginous sands, which are unfossiliferous, and suggested that they belonged to the Woolwich and Reading series. In a postscript to this paper we are informed that the palæontologist W. H. Baily had examined Lenham fossils and pronounced them to be of London Clay origin.

In a later paper Von Koenen [2] regarded the ferruginous sandstones of Kent as corresponding with the Red Crag on account of the presence more particularly of *Arca lactea, Scalaria foliacea, Emarginula fissura*, and *Terebratula grandis*.

Writing on the "Box-stones" of East Anglia, Sir Ray Lankester [3] thought it very probable they were of the same age as the Lenham Sandstones; the former he considered as belonging to the Diestian series of Belgium, and approximately equivalent to the so-called Black Crag of Antwerp. The Belgian geologist Mourlon [4] next recognized that the "Sables de Diest" occurred on the North Downs of Kent, between Folkestone and Dorking, Paddlesworth, and Lenham near Maidstone, as first indicated by Prestwich and Lyell. Messrs. Cogels and O. Van Ertborn [5] alluded to Lyell's statement as to the abundant occurrence of *Terebratula grandis* in the ironstones of the North Downs, which was also found in the Diestian beds of Belgium, this horizon being considered of Lower Pliocene age and not Miocene as understood by Lyell.

A great advance in our knowledge of the Lenham deposits was next made by Mr. Clement Reid,[6] who regarded the beds as Older Pliocene of Coralline Crag age, and equivalent to the Lower Crag or Diestian of Belgium. He recognized that the St. Erth Beds were of similar age and not newer. Speaking of the Lenham Mollusca, he stated that *Arca diluvii* was new to England, and that *Pleurotoma consobrina* (?) and *P. jouanneti* (?) were species belonging to the Upper Miocene of the Continent. His list of determinations, endorsed by Messrs. Sharman and E. T. Newton, included 16 Gastropods, 21 Pelecypods, and 1 Brachiopod.

Four years later fuller particulars of the Lenham deposits were published by the same author [7] in a memoir on the British Pliocenes. They were alluded to as occurring in pipes of the Chalk formation,

[1] "Note on supposed Remains of the Crag on the North Downs near Folkestone": Quart. Journ. Geol. Soc., vol. xxii, p. 553, 1866.

[2] "On the Belgian Tertiaries": GEOL. MAG., 1867, p. 502.

[3] "Contributions to a Knowledge of the Newer Tertiaries of Suffolk and their Fauna": Quart. Journ. Geol. Soc., vol. xxvi, pl. xxxiv, figs. 5–10, p. 499, 1870.

[4] *Géologie de la Belgique*, vol. i, p. 268, 1880.

[5] "Contribution à l'Etude des Terrains Tertiaires de la Belgique": Bull. Soc. R. Mal. Belgique, vol. xvii, pp. xliii–xlv, 1882.

[6] "The Pliocene Deposits of North-Western Europe": *Nature*, vol. xxxiv, pp. 341–3, 1886.

[7] *The Pliocene Deposits of Britain—Lenham Beds (Diestian)* (Mem. Geol. Surv.), 1890, pp. 2, 42–58, etc.

frequently at considerable heights above the sea, near Lenham itself being found at 680 feet above sea-level. The whole of the British Pliocene series were grouped into "Newer" and "Older", the latter containing the following divisions:—

OLDER PLIOCENE.

St. Erth Beds.	Lenham Beds.
Coralline Crag.	Box-stones.

In connection with the Lenham Mollusca it was stated that such southern genera as *Ficula* (*Pyrula*), *Xenophora* (*Phorus*), *Triton*, and *Avicula*, occurring in association with a profusion of *Arca diluvii*, *Cardium papillosum*, and some South European extinct species of *Pleurotoma* and *Terebra*, represented a fauna in favour of a southern or Mediterranean origin.

A full list of fossils from the Lenham and other Pliocene deposits of England was given in tabular order, showing the distribution of each species in Belgium, France, etc., the Lenham shells alone including 65 species, made up of 27 Gastropoda, 1 Scaphopoda, 36 Pelecypoda, and 1 Brachiopoda, as follows:—

GASTROPODA.

Actæon tornatilis, Linnæus.
Aporrhais pespelicani, Linnæus.
Buccinum dalei, J. Sowerby.
Cancellaria contorta, Basterot.
Cerithium tricinctum, Brocchi.
Cypræa europæa, Montagu.
Emarginula fissura, Linnæus.
Eulima subulata, Donovan (?).
Fissurella græca, Linnæus.
Margarita trochoidea, S. V. Wood.
Nassa prismatica, Brocchi.
Natica millepunctata, Lamarck.
N. varians, Dujardin.
Pleurotoma consobrina, Bellardi.
P. jouanneti, Desmoulins.
P. turrifera, Nyst.
Pyrula reticulata, Lamarck.
Ringicula ventricosa, J. Sowerby.
Scalaria clathratula, Adams.
Scaphander lignarius, Linnæus.
Terebra acuminata, Borson.
Triton heptagonum (?), Brocchi.
Trochus cinerarius, Linnæus.
T. millegranus, Philippi.
T. ziziphinus, Linnæus.
Turritella planispira, S. V. Wood.
Xenophorus sp.

SCAPHOPODA.

Dentalium dentalis (?), Linnæus.

BRACHIOPODA.

Terebratula grandis, Blumenbach.

PELECYPODA.

Arca diluvii, Lamarck.
A. lactea, Linnæus.
Artemis exoleta, Linnæus.
Astarte basteroti, Lajonkaire.
A. omalii, Lajonkaire.
A. galeottii, Nyst.
Avicula phalænoides (?), S. V. Wood.
Cardita senilis, Lamarck.
Cardium papillosum, Poli.
Cardium, n.sp.
Cyprina islandica, Linnæus.
Cytherea chione, Linnæus.
Diplodonta astartea (?), Nyst.
D. dilatata, S. V. Wood.
Donax politus, Poli.
Gastrana fragilis, Linnæus.
Hinnites cortesyi, Defrance.
Isocardia cor, Linnæus.
Leda semistriata (?), S. V. Wood.
Lepton deltoideum, S. V. Wood.
Lima loscombii (?), G. B. Sowerby.
Lutraria elliptica, Lamarck.
Mactra arcuata, J. Sowerby.
Nucula sulcata, Bronn.
Ostrea princeps, S. V. Wood.
Pecten maximus, Linnæus.
P. princeps, J. Sowerby.
P. varius, Linnæus.
Pecten, n.sp.
Pectunculus glycimeris, Linnæus.
Pholadidea papyracea, Solander.
Solen ensis, Linnæus.
Tellina benedeni, Nyst.
T. donacina, Linnæus.
Thracia pubescens, Pulteney.
T. ventricosa, Philippi.

The next paper of importance was by Mr. F. W. Harmer,[1] in which the Lenham Beds were regarded as of older age than the Coralline Crag, on account of the more southern facies of the fauna, some of the molluscan species being characteristic of Miocene or Italian Lower Pliocene, which are unknown or rare in the Coralline Crag. The author included a distribution table of shells from the Belgian Diestian beds, showing the Lenham occurrence as well as those found in the "Box-stones" of Suffolk. In the following year the same author[2] referred the Lenham Beds to the Older Pliocene under the new horizonal term of "Lenhamian", and further recognized them in a classification table as belonging to the "zone of *Arca diluvii*", and of the age of the Diestian sands.

A more extended scheme of the Pliocene deposits of the East of England was again published by Mr. Harmer,[3] based on his classification table of 1899. In this the Older Pliocene beds were divided into:—

Lenhamian.	Lenham Beds: Zone of *Arca diluvii*.		Diestian.
	Box-stones	Base of Red Crag.	Waenrode Beds (?).
		Base of Coralline Crag at Sutton.	

The Coralline Crag deposits were scheduled as the basement of the Newer Pliocene series of rocks, which he had formerly placed in the Older Pliocene.

Mr. W. P. D. Stebbing[4] next announced the discovery of some molluscan remains in a patch of sand and ironstone at Netley Heath, Surrey, between Dorking and Guildford, along the top of the North Downs, at heights varying from 570 to 600 feet O.D. The specimens, consisting of sandstone casts, were referred to the genera *Cyprina* (?), *Modiola*, *Nassa*, *Trochus*, *Cardium*, *Pectunculus*, *Tellina*, and *Thracia*, no specific determinations being given. The author inclined to the view that these sandy deposits were a westerly extension of the Lenham Beds near Maidstone, and those at Paddlesworth north of Folkestone.

Referring to the Lenham fossils, which Mr. E. Van den Broeck[5] had examined at the Museum of Practical Geology, that author was of opinion that they represented a fauna of Diestian age. He noted the presence of older forms corresponding to the Bolderian (Upper Miocene) fauna of Belgium, and among the Box-stones at the Ipswich Museum he identified species found in the Belgium Miocene. He concluded, therefore, that the Lenham Beds were Diestian, and that the Box-stones corresponded with the Bolderian of Belgium, or

[1] "The Pliocene Deposits of the East of England; the Lenham Beds and the Coralline Crag": Quart. Journ. Geol. Soc., vol. liv, p. 308, 1898.

[2] "On a proposed new Classification of the Pliocene Deposits of the East of England": Rep. Brit. Assoc. (Dover), 1899, p. 752.

[3] "The Pliocene Deposits of the East of England, part ii: The Crag of Essex (Waltonian) and its Relation to that of Suffolk and Norfolk": Quart. Journ. Geol. Soc., vol. lvi, p. 708, 1900.

[4] "Excursion to Netley Heath and Newlands Corner": Proc. Geol. Assoc., vol. xvi, pp. 524–6, 1900.

[5] "Le Diestien et les Sables de Lenham, le Miocene démantelé et les Box-Stones en Angleterre": Bull. Soc. Belg. Géol. (Bruxelles) Procès-verbaux, vol. xvi, pp. 170–3, 1902.

DISTRIBUTION TABLE OF THE LENHAM MOLLUSCA AND BRACHIOPODA.

GENERA AND SPECIES.	GEOLOGICAL HORIZONS.																		
	Aquitanian.	Burdigalian.	Vindobonian.	Redonian.	Messinian.	Box-stones.	Lenham Beds.	St. Erth Beds.	Coralline Crag.	Bolderian.	Anversian.	Diestian.	Scaldisian.	Plaisancian.	Astian.	Red Crag.	Norwich Crag.	Post-Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GASTROPODA—																			
Capiluna græca, Linnæus, sp.			x	x			x		x				x			x			x
Emarginula fissura, Linnæus, sp.				x			x		x		x		x	x	x	x			x
Eumargarita trochoidea, S. V. Wood, sp.							x						x			x		x	x
Calliostoma zizyphinum, Linnæus, sp.						x	x	x	x			x	x			x			x
Ampullotrochus miliaris, Brocchi, sp.			x		x		x	x	x		x			x	x				x
Capulus ungaricus, Linnæus, sp.			x	x			x	x	x			x	x			x		x	x
Trivia europæa, Montagu, sp.			x	x			x	x	x		x	x	x	x	x	x		x	x
Ptychopotamides tricinctus, Brocchi, sp.			x	x			x	x					x	x	x	x	x	x	
Scala subulata, J. de C. Sowerby, sp.							x		x			x	x			x			(?)
Hyaloscala clathratula, Kanmacher, sp.				x			x		x			x	x						x
Pyramidella plicosa, Bronn, sp.			x		x		x		x		x			x	x	x			
Subularia subulata, Don., sp.			x		x		x	x	x		x	x	x	x	x				x
Zaria subangulata, Brocchi, sp.			x		x		x	x	x		x			x	x				
Xenophora crispa (?), König, sp.							x							x	x				
Aporrhais pespelecani, Linnæus, sp.			x				x		x		x	x	x	x	x	x	x	x	x
Semicassis saburon, Brug., sp.			x		x	x	x				x		x	x	x	x			x
Ficus reticulata, Lamarck			x	x	x	x	x		x	x	x	x		x	x	x			x
Streptochetus sexcostatus, Beyrich, sp.			x		x		x				x								
Tritia limata, Chemnitz, sp.		x	x	x	x		x		x		x		x	x	x				x
Murex badensis, Nyst			x				x		x				x			x			
Boreotrophon clathratum, Linn., sp.							x		x	x						x	x	x	x
Trophonopsis muricatus, Montagu, sp.				x			x						x			x		x	x
Bonellitia serrata, Bronn, sp.			x				x							x					
Maculopeplum lamberti, J. Sow., sp.			x	x		x	x		x			x	x			x			
Turris turrifera, Nyst, sp.			x		x		x			x	x	x	x	x	x	x		x	
Drillia obeliscus, Des Moul., sp.		x	x		x		x			x	x	x							
Clavatula jouanneti, Des Moul., sp.		x	x				x												
Terebra acuminata, Borson			x		x		x				x			x	x				
Actæon tornatilis, Linnæus, sp.			x		x		x		x		x	x	x	x	x	x	x		x
Ringiculella lenhamensis, sp.n.							x												
Scaphander lignarius, Linnæus, sp.			x	x	x		x		x	x	x	x	x	x	x	x			x
Bullinella cylindracea, Pennant, sp.			x	x	x		x		x		x	x	x	x	x	x			x
SCÁPHOPODA—																			
Dentalium entale, Linnæus			x		x	x	x				x	x	x	x			x	x	x
PELECYPODA—																			
Nucula proxima, Say							x	x	x		x							x	x
Nucula cf. *sulcata*, Bronn			x				x	x						x	x				x
Yoldia oblongoides, S. V. Wood, sp.							x									x	x	x	

DISTRIBUTION TABLE—(*continued*).

GENERA AND SPECIES.	GEOLOGICAL HORIZONS.																		
	Aquitanian.	Burdigalian.	Vindobonian.	Redonian.	Messinian.	Box-stones.	Lenham Beds.	St. Erth Beds.	Coralline Crag.	Bolderian.	Anversian.	Diestian.	Scaldisian.	Plaisancian.	Astian.	Red Crag.	Norwich Crag.	Post-Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
PELECYPODA (*continued*)—																			
Monia patelliformis, Linnæus, sp.							x		x					x	x	x	x	x	x
Anadara diluvii, Lamarck, sp.			x		x		x			x	x			x					
Fossularca lactea, Linnæus, sp.			x	x			x		x					x	x	x		x	x
Glycymeris pilosa, Linnæus, sp.			x	x	x	x	x	x	x		x	x	x		x				x
Mytilus edulis, Linnæus, var. *ungulatus*, Poli							x									x			x
Volsella barbata, Linnæus, sp.							x							x		x			x
Margaritifera phalænacea, Lamarck, sp.	x	x	x				x		x		x			x					
Ostrea princeps, S. V. Wood							x		x			x	x			x			
Pecten maximus (?), Linnæus, sp.							x	x	x		x	(?)	x			x			x
Æquipecten opercularis, Linnæus, sp.					x	x	x	x	x			x	x	x	x	x	x	x	x
Manupecten pesfelis, Linnæus, sp.			x	x			x							x	x				x
Chlamys princeps, J. de C. Sow., sp.							x		x				x				x		
Hinnites crispus, Brocchi, sp.					x	x	x		x					x	x	x			
Glans senilis, Lamarck, sp.			x	x			x		x				x			x			
Astarte basteroti, Lajonkaire				x			x		x			x	x			x			
A. galeottii, Nyst							x		x				x			x			
A. omalii, Lajonkaire			x	x			x		x	x	x	x	x			x		x	
A. mutabilis, S. V. Wood							x		x		x		x			x			
Cyprina rustica (?), J. Sowerby, sp.			x		x	x	x		x		x	x	x			x			
Isocardia humana (=*cor*), Linn., sp.			x				x		x			x				x			x
Dentilucina borealis, Linnæus, sp.			x	x	x		x	x	x		x	x	x	x	x	x	x	x	x
Arcopagia ventricosa, Serres, sp.			x				x							x	x				
Tellina benedeni, Nyst & West			x		x		x			x	x	x	x			x			
Moera donacina, Linnæus, sp.			x				x		x				x	x	x	x		x	x
Gastrana laminosa, J. de C. Sow., sp.							x		x				x			x			
Spisula arcuata, J. Sowerby, sp.							x			x		x	x			x	x	x	
S. subtruncata, Da Costa, sp.			x	x		x	x	x	x				x	x	x	x	x	x	x
Pitar rudis, Poli, sp.			x	x			x		x				x	x	x	x		x	x
Callista chione, Linnæus, sp.			x	x			x		x	x	x	x	x	x	x	x			x
Tapes perovalis, S. V. Wood							x		x										
Papillicardium papillosum, Poli, sp.			x	x	x		x	x						x	x				x
Plagiocardium hirsutum, Bronn			x				x							x	x				
Ensis ensis, Linnæus, sp.			x	x			x	x	x		x	x	x	x	x	x		x	x
Cyrtodaria angusta, Nyst & West, sp.					x	x	x		x	x	x	x	x			x			
Panopæa menardi, Deshayes			x		x	x	x		x		x					x			
Barnea cylindrica, J. Sowerby, sp.							x									x			
Aspidopholas rugosa, Brocchi, sp.							x							x	x				
Pholadidea papyracea, Turton, sp.				x			x		x		x	x							x
Thracia convexa, W. Wood			x			x	x		x					x	x			x	x
T. pubescens, Pulteney, sp.			x				x		x				x	x	x			x	x
BRACHIOPODA—																			
Terebratula perforata, Desnoy				x			x		x	x	x	x	x			x			

probably a more recent horizon which represented the Mio-Pliocene or Older Pliocene, a period slightly anterior to the Diestian. He was also of opinion that the zones of *Terebratula grandis* and *Isocardia cor* could not be separated, but belonged alike to the Diestian division of the Pliocenes.

In a further contribution, Mr. Harmer[1] regarded the Lenham Beds as synchronous with the ferruginous sandstones of Louvain and Diest. He stated that among the Diestian sandstone fossils were about sixty species of Mollusca, some being Crag forms, whereas a few were of an older or Miocene type and not found in the Coralline Crag; similarly the Lenham shells included many Miocene species, such as *Terebra acuminata*, *Triton heptagonum*, *Pleurotoma consobrina*, *P. jouanneti*, *Cancellaria contorta*, *Hinnites cortesyi*, and *Arca diluvii*. A table of the British Pliocene deposits was included, being nearly similar to that issued by the same author in 1900, in which the "Lenhamian" formed the lowest of the Pliocene stages, the Box-stones being regarded as equivalent to the Waenrode Beds of Belgium (Bolderian, according to Mr. Van den Broeck).

Subsequently Mr. Harmer[2] repeated his former views on the age of the Lenham deposits, the fauna being spoken of as presenting a distinctly older type than that of the Coralline Crag and approaching more nearly a Miocene facies, instancing, among other shells, the abundance of *Anadara diluvii*, which occurs in the Vienna Basin, the Touraine area of France, and the Bolderian of Belgium.

In their memoir on the geology of Holland, Messrs. G. A. F. Molengraaff and A. J. M. Van Waterschoot Van der Gracht[3] referred to the occurrence of *Anadara diluvii* in the Lenham Beds as indicative of a Miocene age, the same shell being found in the Miocene deposits of Peel and Winterswyk in Holland, the rocks of the former place being stated as the equivalent of the "Glimmertons" of the north of Germany or the Tortonian stage of the Miocene, whilst the beds at Winterswyk were regarded as Middle Miocene. This work also included lists of molluscan species from the Upper and Middle Miocene deposits of Holland, many of which are found in the Lenham Beds.

Another reference to the geological aspect of this subject has been made by Mr. F. W. Harmer[4] in an "Introduction" to a new work on British Pliocene Mollusca, where he adheres to his previously expressed views that the Lenham Beds with the "Box-stones" and the Belgian Diestian deposits should be grouped as Lower Pliocene and that the Coralline Crag beds of East Anglia should form the base of the Upper Pliocenes.

A final notice to make involves a slight alteration in the views of Mr. C. Reid,[5] who, in a work recently published, places the Coralline

[1] "A Sketch of the Later Tertiary History of East Anglia": Proc. Geol. Assoc., vol. xvii, pp. 416–79, 1902.

[2] "The Pliocene Deposits of the Eastern Counties of England": Geol. Assoc., Jubilee Volume, 1908, pp. 86–102.

[3] "Niederlande": Handb. Region. Geol., vol. i, pt. iii, pp. 51–3, 1913.

[4] *The Pliocene Mollusca of Great Britain* (Mon. Pal. Soc.), 1914, pt. i, p. 5.

[5] C. & E. M. Reid, "The Pliocene Floras of the Dutch-Prussian Border": Mededeel. Rijks. Delfst., 1915, No. 6, p. 9.

Crag and Lenham Beds in the Lower Pliocene group, bracketing them as equivalent to the Diestian—but the "Box-stones" are scheduled as Miocene.

(*In July will follow Mr. Newton's conclusions.*)

II.—The Horizon of the Type-specimens of Dr. Scouler's *Dithyrocaris tricornis* and *D. testudinea*. By Peter Macnair, F.R.S.E., F.G.S.[1]

Introduction.

THE exact locality and as a consequence the precise geological horizon from which the type-specimens of *Dithyrocaris tricornis* and *D. testudinea* were obtained has long been a matter of considerable uncertainty. These type-specimens, now preserved in Kelvingrove Museum, were first described by Dr. John Scouler in the *Records of General Science* for the year 1835 (p. 137). The object of this paper is to demonstrate that these fossils came from what was known as the Gallowhill Quarries, and that they occupy a position near the top of the Blackbyre Limestone of this district.

Regarding the beds in which they were found Dr. Scouler says: "This limestone is situated about a mile to the east of Paisley, and was first pointed out to me by Mr. Murray, of the Glasgow Botanic Gardens. This rock is distinct from and probably reposes on the true Carboniferous Limestone, but as only a small patch of it is exposed, the greater part being covered by the soil, it was impossible to trace its relations with the subjacent strata. This limestone is of an extremely compact nature, with little plates of calcareous spar disseminated through its substance. It readily splits into flags of variable thickness, which are sometimes made of a multitude of extremely thin layers, indicating that the whole stratum has been formed by the gradual and tranquil deposition of transported matters. The organic matters differ widely from those which we observe in the Carboniferous Limestone. I could detect no *Productidæ* nor any fragments of corals or stems of crinoid animals, nor, in short, any decidedly massive production. Instead of these, on splitting up the rock we observe impression of ferns of great variety and beauty, the remains of entomostraca, which are of gigantic size when compared with the analogous species which still abound in our lakes and pools. Two species belonging to a new genus were obtained, and the numbers might have been greatly increased had not the hardness of the rock rendered the extraction of the specimens a difficult task." It will be noted that though in the above account no definite locality is mentioned, yet they are recorded as coming from a locality about a mile to the east of Paisley. Another important feature of this account is that it is such an exact description of the nature of the limestone in which the fossils occur that we can have no hesitation in identifying it with the bed to be described subsequently in this paper.

[1] Reprinted in a slightly abridged form from the Transactions of the Geological Society of Glasgow, vol. xvi, pt. i, 1915–17.

In the *New Statistical Account of Scotland*, published in 1845, under the section "Town and Parishes of Paisley", we find the following important reference to this limestone and these fossils (1845, p. 157). It is of very great interest, because it appears to have hitherto escaped notice, and because it cites the Farm of Gallowhill as the exact locality where the fossils were obtained. The reference runs as follows: "To the north-east of Paisley, on the Farm of Gallowhill, a quarry has of late been wrought in an extensive bed of schistose rock lying almost horizontally about 3 feet below the surface. Its colour is dark grey approaching to black. Its texture is compact and fine grained, and it readily splits into layers, but is with difficulty broken across. The fracture is splintery and rather conchoidal. It is composed of about 32 per cent. of carbonate of lime, 47 of sand, and 9 of alumina. This rock abounds in beautiful specimens of many genera and species of ferns, as also of shells, chiefly Terebratula, Nucula, and Orthoceratites. The layer of till immediately above this rock for several inches closely resembles Fuller's earth." The most interesting point, however, bearing upon the locality from which Scouler obtained his fossils is contained in the following footnote, which is added: "Two species found here belonging to a rare genus are described by Dr. Scouler in Thomson's Records of General Science, vol. i."

In 1865 Mr. James Armstrong (1865, p. 74) states in a paper published in the *Transactions* of this Society that specimens of *Dithyrocaris* were obtained by Dr. Scouler upwards of thirty years ago in a limestone excavated for the foundations of the Paisley Barracks.

In a paper read to the Society in 1893 Mr. James Neilson (1893, p. 71) makes the following statement regarding the locality where the type-specimens of *Dithyrocaris tricornis* and *D. testudinea* were found: "It is worthy of notice that when the late Dr. Scouler first discovered *Dithyrocaris* at Inkerman, near Paisley, nearly the entire animal was got. These beds were afterwards lost, and during many years since, the finding of only one or two carapaces has been recorded." From this it will be seen that Mr. Neilson, in utter disregard of any of the foregoing statements as to the locality at which the specimens were got, has shifted it to Inkerman, 1½ miles west of Paisley. But he gives us no reason for his doing so, and I am utterly unable to understand upon what grounds it was made.

In their memoir on the British Palæozoic Phyllocaridæ Professor T. Rupert Jones and Dr. Henry Woodward (1898, p. 147) still further complicate the matter, for in the text they say that Dr. Scouler's original specimen of *Dithyrocaris testudinea* is in hard, black, earthy limestone from the Carboniferous Limestone Series about a mile to the east of Paisley, the latter part of the sentence being quoted from Dr. Scouler's paper. But in a footnote they say, "At a place now called Inkerman, where Mr. R. Dunlop has lately most obligingly sought for further indications of these fossils, but without success." In this footnote they have evidently been misled by Mr. Neilson.

As we have already said, we hope to show that the statement made by the authors of the *Statistical Account* is probably the correct one,

and that the specimens were got in a peculiar limestone which was formerly quarried on Gallowhill Farm, 1½ miles to the north-east of Paisley, and that both Mr. Armstrong's and Mr. Neilson's statements as to the locality where they were found are erroneous.

THE TYPE-SPECIMENS OF *DITHYROCARIS TRICORNIS* AND *D. TESTUDINEA*.

The type-specimens of the two species of *Dithyrocaris* were originally presented to the Anderson College Museum by Dr. Scouler, and some years ago were gifted, along with other specimens, to Kelvingrove Museum by the Governors of the Royal Technical College. *D. tricornis* shows the two valves of the carapace lying in an almost symmetrical position, but reversed so that the anterior part is approximately in the position that the posterior part ought to be, a phenomenon not unusual in decaying and floating Phyllopods.

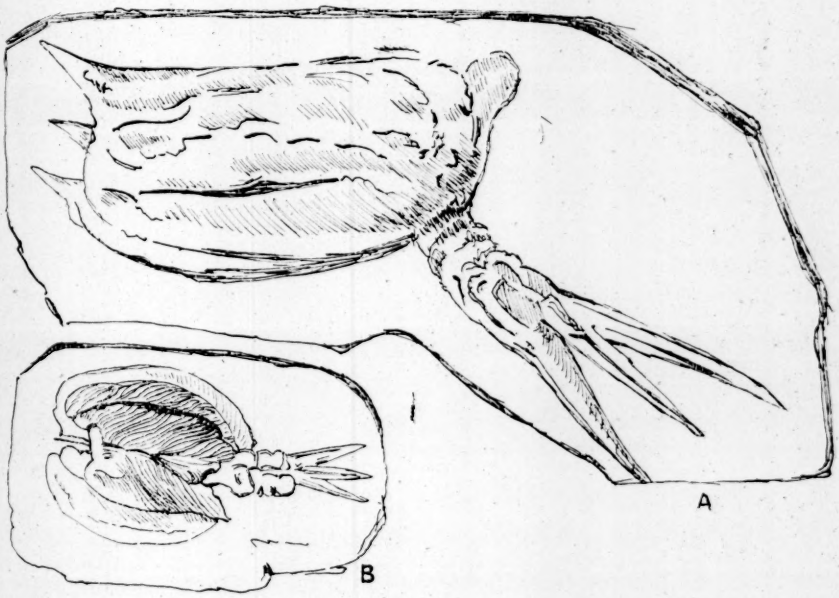

FIG. 1.—A. *Dithyrocaris tricornis*, Scouler. B. *D. testudinea*, Scouler. From the original drawings in Scouler's paper. The type-specimens are now in Kelvingrove Museum.

The three somewhat obscure abdominal segments and a tail with three spines project from the lower part of the front of the carapace. The gastric teeth are exposed through the test.

In *Dithyrocaris testudinea* the broad oval carapace is semi-elliptical in shape. The two valves lie in opposition by their dorsal edges, and overlap irregularly towards the lower half of the dorsal region. In both valves the central border is seen to terminate in a small obscure spine. A strong ridge showing the characteristic rugose structure of the overlapping chevron-shaped scales runs down the

middle of each valve. The abdominal segments which project from behind the carapace have been considerably crushed. The three caudal spines are well shown. They are of nearly equal length, stout, fluted, and show traces of granulation on the riblets. Fig. 1, which shows *Dithyrocaris tricornis* and *D. testudinea*, is after the original drawing in Dr. Scouler's paper.

The only other fossil preserved on the slabs containing the type-specimens is a single specimen of *Lingula mytiloides*, which is seen on the large slab with *Dithyrocaris tricornis*. As we shall presently see, this is the commonest of all the fossils found in the Gallowhill Limestone, in which it is often exceedingly numerous.

The Gallowhill Limestone.[1]

About two years ago my attention was first directed to the peculiar character of the limestone that forms the wall to the east of Gallowhill, near Paisley. The locality from which Scouler's type fossils had been obtained had for a long time exercised my mind, as it had done that of other local geologists, and when I first saw the limestone of which the wall is built I was at once struck with its strong similarity to that forming the matrix of the Scouler fossils. I took a specimen of the limestone with me, and a comparison of it with the specimens in the museum at once confirmed their identity. Both present the same earthy-like appearance, their joint faces being lined with calcite, and strongly charged with iron pyrites in nodular masses and in strings and isolated cubes. Associated with the limestone are bands of a much more argillaceous and sandy nature, of which examples may be seen in the dykes and bings, the large bing to the south of Gallowhill House having yielded numerous examples of the different types of sedimentation that appear to have prevailed upon this horizon. I am indebted to Mr. R. S. Houston for the following analysis of the limestone, which, like the analysis given in the *Statistical Account*, shows that it contains a large percentage of siliceous and clayey matter:—

Carbonate of lime	48·67
Carbonate of magnesia	·98
Carbonate of iron	5·70
Alumina	1·02
Siliceous matter (clay)	40·23
Carbonaceous matter	2·30
Moisture	·57
	99·47

After convincing myself of the lithological identity of the two limestones I began to search for some evidence of a Phyllopod fauna, and was soon rewarded by clear evidence of its presence. Nothing to equal Scouler's specimens has yet been found, but fragments of carapaces and tail spines are sufficiently numerous and in a similar state of preservation to conclusively demonstrate the identity of the

[1] It should be clearly understood that the local term "Gallowhill Limestone" used throughout this paper does not stand for any new limestone horizon, but is only used to express a peculiar phase occurring at the top of the Blackbyre Limestone. This, indeed, is the main object of the paper.

Gallowhill Limestone with that which forms the matrix in which Scouler's fossils are preserved. The most abundant fossil in the Gallowhill Limestone is *Lingula mytiloides*, many of the slabs being simply crowded with them. The full significance of the faunal association found in the Gallowhill Limestone will, however, be discussed in more detail presently. In his paper Scouler refers to the absence of Productidæ, corals or stems of crinoid animals, but *Productus longispinus* and *Rhynchonella pleurodon* are fairly abundant on some slabs. Slabs of the limestone rich in crinoidal remains have also been observed. But whether these represent the same bed as that which carries the Phyllopod fauna or one on a slightly different horizon we have not yet been able to determine definitely, but we are inclined to favour the latter view.

Arkleston Cutting and Former Exposures at Gallowhill.

In my paper on the Hurlet sequence in North Ayrshire I have given an account of the strata exposed in the Arkleston Cutting, and it is there shown that the top limestone is the Hurlet Limestone, here 3 to 4 feet thick and dipping towards the east. Below it comes the Hurlet Alum Shale, only some 6 inches thick, followed by the Hurlet Coal, originally from 5 to 6 feet thick. The coal has been split up the centre by a sill of dolerite, some 80 feet in thickness, lenticles of the coal occurring within the sill. Below the sill comes some 18 feet of shale and fireclay, in which there is a limestone in three seams full of entomostraca and fish remains, and which is clearly the equivalent of the Baldernock Limestone of the Campsie district. The whole group of sedimentary strata is much pyritized and altered by contact with the intrusive sill of dolerite. A search for the alum shale fauna in the fragments that are seen to lie above the sill has not as yet been successful in yielding any examples of that characteristic fauna, as the shale is very completely baked. But the discovery of the fauna at this point is not yet regarded as entirely hopeless. I have also shown in the paper mentioned that a highly fossiliferous limestone was at one time exposed between the bridge and the signal box, and that, dipping towards the east, it passed beneath the strata in the cutting just described. A consideration of all the available palæontological and stratigraphical evidence goes to show that this limestone must have been the equivalent of the Blackbyre Limestone.

If we turn to the 6-inch-to-the-mile Geological Survey map, of which Fig. 2 is in part a reproduction, it will be noticed that the limestone, there shown as trending northwards towards the Arkleston Print Works, and then bifurcating into two outcrops towards the north-west, clearly lies below the sill now seen in the cutting. When the Geological Survey map was made in the year 1875 the railway ran through a tunnel at this point, and the Hurlet Limestone lying above the sill does not appear to have been exposed. If it was it is not indicated on the map. The limestone represented on the map is drawn as two narrow outcrops at the Paisley end of the tunnel. Unfortunately no exposure can now be observed between the bridge over the railway and the signal box. But that a limestone was at

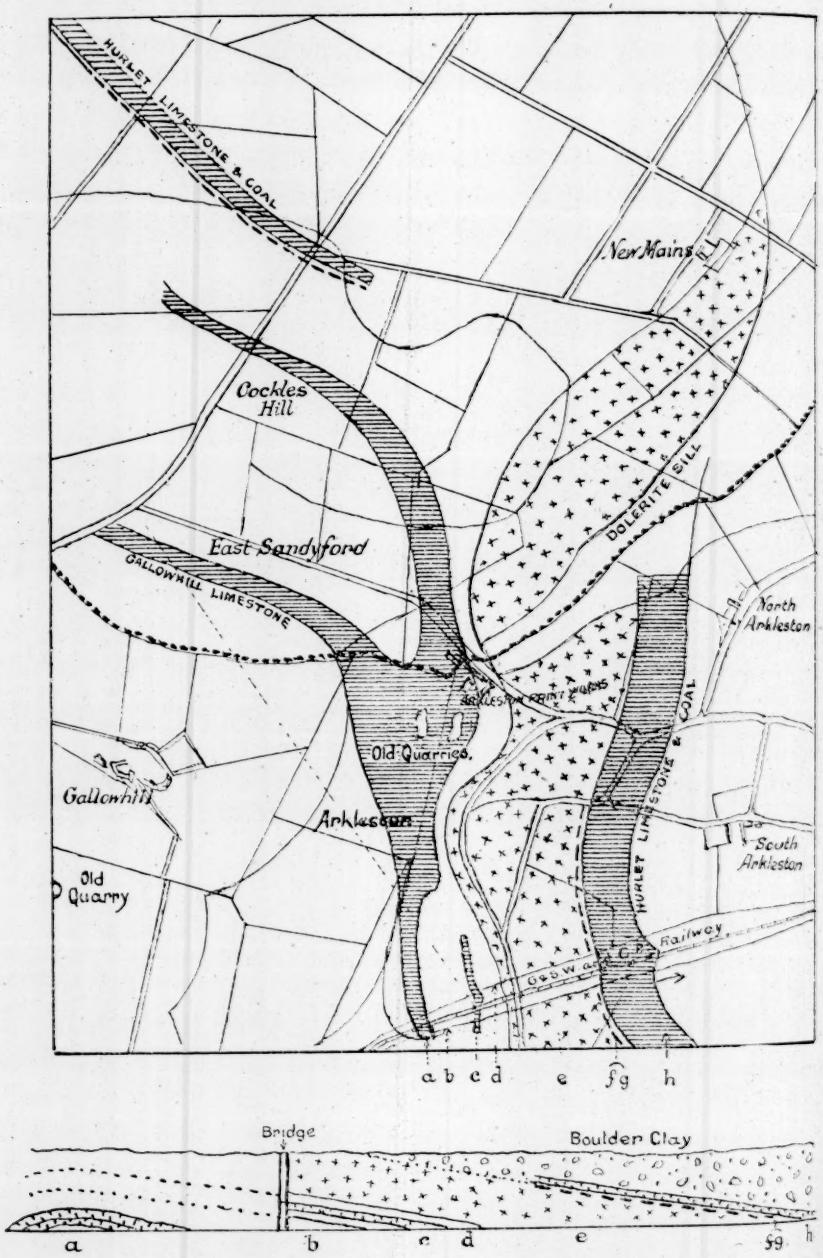

FIG. 2.—Sketch-map and section along the railway at Arkleston, Paisley. *a*, Blackbyre Limestone with Gallowhill Limestone phase at top; *b*, Cementstone with rootlets; *c*, Entomostracan Limestone; *d*, shales and fireclay; *e*, dolerite sill; *f*, Hurlet coal; *g*, alum shale; *h*, Hurlet Limestone.

one time exposed at this point is made clear both by the Survey map and by Mr. Blair's paper published in our Transactions (1889, p. 133). In this paper Mr. Blair describes it as exhibiting "a wider variety and more abundant quantity of delicate organisms than I have yet seen in any of these deposits".

The section between the railway bridge and the signal box at the Paisley end of the cutting is now so completely grassed over that not a vestige of rock can now be seen, and we are left to judge by analogy with the general sequence of the district what the horizon of the limestone formerly exposed at this point may be. Fortunately, though exposures are extremely rare upon this horizon in this district, yet the cumulative evidence is such as to leave no room for any doubt in our minds that the limestone formerly exposed at this point, known locally as the Gallowhill Limestone, must be the equivalent of the Blackbyre Limestone of the Hurlet type section. On the east side of the railway bridge the lowest bed seen in the railway cutting is a band of grey cement limestone with rootlets, which all over this area is a well-marked horizon lying immediately below the Hurlet Coal and above the Blackbyre Limestone. It can be seen at Crookston Farm cropping from below the dolerite sill in exactly the same fashion as it does in this cutting, but there in addition to the rootlets it contains fish teeth, *Spirorbis*, and entomostraca.

Below this rooty cementstone there comes in the Hurlet district a variable thickness of shales succeeded by the Blackbyre Limestone. This view has been expressed in the section in Fig. 2; *a* is the Gallowhill Limestone, being the top of the Blackbyre Limestone, shown as folded into a gentle arch, which gives off in its eastern limb, *b* the cement limestone with rootlets, *c* thin bands of limestone with entomostraca and fish remains, *d* beds of shale and fireclay, *e* intrusive sill of dolerite, *f* and *g* Hurlet Coal and alum shale, and *h* Hurlet Limestone.

As has already been stated, no exposures of the Gallowhill Limestone can now be seen at any of the localities where it was formerly worked. But the position of two of the quarries south of the Arkleston Print Works can still be seen. Another quarry appears to have been opened a little to the south of Gallowhill, opposite the Mote Hill. The positions of these quarries are indicated on the map, and they seem to have been somewhat extensively worked about the year 1835, when Scouler's fossils were found, the old Powder Magazine between Arkleston and South Arkleston having been built of it, as well as a large number of the dykes in the Gallowhill Policies. It was also used in some walls in the neighbourhood of the Paisley Barracks, where it can still be seen. This may have something to do with Armstrong's statement that Scouler's fossils were found in a limestone excavated for the foundations of the Paisley Barracks.[1] That the Gallowhill Limestone must extend considerably

[1] Since writing this paper I have been informed by Mr. R. Houston that in making the foundations for the villas adjoining the Paisley Barracks it was found that slabs of the Gallowhill Limestone had been used to fill up old hollows in the surface of the ground.

to the west of the outcrop, as drawn on the map, is made clear both from the evidence derived from the old quarry opposite the Mote Hill and also from recent information that we have obtained which shows that Gallowhill House rests upon it. But whether it is continuous over this area or is repeated by faulting we have no data to decide, and the position of the outcrop is left much as it is given in the 6-inch-to-the-mile Geological Survey map.

The statement in the *Statistical Account* that the layer of till immediately above the Gallowhill Limestone for several inches closely resembles fuller's earth is of great interest, as we seem to recognize in this the peculiar ashy fireclay which is generally found to rest on the eroded top of the Blackbyre Limestone of Renfrewshire and North Ayrshire.

In interpreting the structure of the ground between Arkleston and the Cart it seems to us that there must be a low arch bringing in the strata that lie immediately below the Hurlet Limestone. On the east this arch sinks below the Hurlet Limestone, as exposed in the Arkleston Cutting, and on the west it must pass below the outcrop of the Hurlet Limestone and Coal which has been drawn by the Survey to cross the White Cart Water near Carlisle Quay and Nethercommon. An exposure of limestone underlaid by a bed of coal with pyrites can at present be seen at low tide immediately below the Swing Bridge at Carlisle Quay, but owing to the limited nature of the exposure it is at present difficult to determine whether this is the Hurlet Limestone or the Blackbyre Limestone, but it is certainly the equivalent of one of these.

Bores put down along the outcrop of the dolerite on the Gallowhill Policies show that the dolerite rests along this line upon a series of thick-bedded shales, fireclays, and sandstones which have been bored into for a depth of more than 30 fathoms. There can scarcely be any doubt that the uppermost of these represent the sediments which lie between the Blackbyre Limestone above and the Hollybush Limestone below. On the 6-inch-to-the-mile Geological Survey map a bore put down to the south of Gallowhill shows the presence of a coarse limestone 1 ft. 7 in. thick at a depth of 12 fathoms. This is probably upon the position of the Hollybush Limestone.

Comparison with the Blackbyre Limestone at other Localities.

From the evidence that has been adduced there can be no doubt that the Gallowhill Limestone must lie somewhere on the horizon of the Blackbyre Limestone, and we now pass to consider the evidence that exists bearing upon the lithological and palæontological characteristics of the Blackbyre Limestone in this district. At the type locality (Blackbyre Farm) the Blackbyre Limestone consists of two parts, a lower full of small Brachiopods, largely *Productus longispinus*, and an upper part which is crinoidal. Neither of these, however, can be compared with the Gallowhill Limestone. As a rule, the Blackbyre Limestone of this district may be described as essentially a Brachiopod or shelly limestone with occasional bands of *Lithostrotion*. The contention of this paper is that the Gallowhill

Limestone is simply a phase characteristic of the top of the Blackbyre Limestone, and as the top of the limestone is not seen at the type locality it is quite possible that it may be present though not exposed.

The section exposed at Jenny's Well, a quarter of a mile to the east of Blackhall, Paisley, is practically a counterpart of that seen in the Arkleston Cutting, and the additional corroborative evidence bearing upon the relationship of the Gallowhill Limestone to the Blackbyre Limestone is so complete that it requires to be examined in some detail. The section shows a fairly continuous sequence from the Blackhall Limestone down to the base of the sill of dolerite which here occupies exactly the same stratigraphical position as in the Arkleston Cutting, having the Hurlet Limestone above and the Blackbyre Limestone below.

Unfortunately the outcrop of the Blackbyre Limestone cannot be seen, but its position is shown by a hollow immediately to the west of the dolerite sill, which runs in a north and south direction from the Cart up the side of Dykebar Hill, marking the line along which it was formerly quarried. Just at the point where the road crosses the railway the Blackbyre Limestone was exposed during the making of the line. It cannot now be seen, but the walls on each side of the railway at this point are built of it, and the blocks of limestone show all the features of the Gallowhill Limestone on the one hand and of the Blackbyre Limestone of the type section on the other.[1]

An examination of the exposure of the Blackbyre Limestone seen in the bed of the Levern at Neilston, a little above the point where it crosses the main road to Lugton, helps, we think, to throw some light upon the relationship of the Gallowhill Limestone to the Blackbyre Limestone. The section here is somewhat obscure, but the main mass of the limestone is rich in corals and Productidæ. The former are represented by bands of *Lithostrotion* and solitary corals, the latter by various species of *Productus* and by numerous specimens of the large variety of *Productus giganteus*. On the top of the main mass of the limestone rests a bed of fine-grained cementstone, which presents all the features of the Gallowhill Limestone. Traced into North Ayrshire, it forms the peculiar fine-grained top of the Dockra Limestone and its equivalents, which we have elsewhere shown to be the same as the Blackbyre Limestone of the Hurlet section.

An examination of the sections exposed in the burn at Meikle Corseford, and on the Gryffe Water below Bridge of Weir, also affords certain evidence which goes to confirm the relationship of the Gallowhill Limestone to the Blackbyre Limestone. At both localities the Blackbyre Limestone is capped by a fine-grained crinoidal limestone comparable to the crinoidal phase of the Gallowhill Limestone. And at both these localities it is overlaid by the peculiar green ashy mud which is probably identical with the so-called fuller's earth found in the Gallowhill Quarry.

[1] The evidence derived from these blocks shows that the Blackbyre Limestone of this locality has a strong resemblance to that exposed in the Beith Quarries. It carries a varied Brachiopod fauna and contains thick bands of *Lithostrotion* and other corals.

The Faunal Association of the Gallowhill Limestone.

The fauna of the Gallowhill Limestone is an exceedingly characteristic one, and has a remarkable resemblance to that which exists on a much higher stratigraphical horizon, the Calderwood Cementstone of the East Kilbride district. So striking is the similarity between the two that we here institute a comparison between them to show that they must have been accumulated under closely similar physical conditions. Both in the Calderwood Cementstone and the Gallowhill Limestone the fossils are but sparingly distributed throughout the limestone, and the rarer forms only occur at wide intervals. The following list gives some of the principal species that occur in the Calderwood Cementstone at such localities as Burnbrae, Jackton Burn, Kirktonholm, Glebe Quarry, and Limekilns House.

Serpulites carbonarius, M'Coy.
S. membranaceus, M'Coy.
Spirorbis caperatus, M'Coy.
Dithyrocaris glabra, Woodw. & Eth.
D. granulata, Woodw. & Eth.
D. ovalis, Woodw. & Eth.
D. testudinea, Scouler.
D. tricornis, Scouler.
Palæmysis, Peach.
Palæcrangon, Salter.
Palæsquilla Pattoni, Peach.
Anthrapalæmon Coutsii, Peach.
Discina nitida, Phill.
Lingula squamiformis, Phill.
Productus semireticulatus, Mart.
P. longispinus, Sow.
Rhynchonella pleurodon, Phill.
Streptorhynchus crenistria, Phill.
Aviculopecten knockonniensis, M'Coy.
Posidonomya corrugata, Eth.
Nuculana attenuata, Flem.
Protoschizodus æquilateralis, M'Coy.
Nucula gibbosa, Flem.
Sanguinolites plicatus, Portl.
Orthoceras attenuatum, Flem.
Nautilus sp.

Serpulites carbonarius occurs in the Calderwood Cementstone, some slabs being simply covered with the tubes of this worm. In the Gallowhill Limestone they occur in exactly similar conditions. I have also found traces of *Serpulites membranaceus* and *Spirorbis caperatus* in the Gallowhill Limestone.

The Phyllopod Crustacea from the Gallowhill Limestone include, besides the two species *Dithyrocaris tricornis* and *D. testudinea*, others whose specific characteristics have not yet been determined. Their mode of occurrence and state of preservation are strongly suggestive of the conditions under which these fossils appear in the Calderwood Cementstone. No traces of the Schizopods which occur in the Calderwood Cementstone have as yet been found in the Gallowhill Limestone, but further search may yet reveal the presence of some of these most interesting forms.

The Brachiopod fauna of the Gallowhill Limestone is strikingly similar to that of the Calderwood Cementstone. In the Carluke district the Calderwood Cementstone is known as the Lingula Limestone, because of the large numbers of that fossil which occur in it. In the Gallowhill Limestone *Lingula squamiformis* is replaced by *Lingula mytiloides*, which, as has already been pointed out, occurs in great numbers. The more common Brachiopods in the Gallowhill Limestone are *Productus longispinus*, *P. semireticulatus*, and *Rhynchonella pleurodon*, and less commonly *Discina nitida* and *Streptorhynchus crenistria*.

Lamellibranchs are exceedingly scarce in the upper part or estuarine phase of the Gallowhill Limestone, but several specimens referable

to *Sanguinolites plicatus* have been found, and one specimen closely resembling *Protoschizodus æquilateralis* and *Posidonomya corrugata* also occurs, and from the lower and more crinoidal parts *Nuculana attenuata* and *Nucula gibbosa* have been obtained.

The Cephalopoda are represented in the upper or estuarine part of the limestone by *Orthoceras attenuatum* and by a *Nautilus* which has not been specifically determined.

Fish remains, in the shape of scales, spines, and plates, occur in the upper part of the limestone, though in a somewhat fragmentary condition. They are clearly referable to those ganoids which are found in the estuarine facies of the Carboniferous formation.

Plant remains are fairly common, principally the fronds of ferns, and occurring as they do in association with the Phyllopods and with *Productus longispinus* and other Brachiopods they tend to accentuate the resemblance between the Gallowhill Limestone and the Calderwood Cementstone.

From what has been said it will be seen that the whole assemblage of plants and animals found in the Gallowhill Limestone is strikingly similar to that which occurs in the Calderwood Cementstone. That these strata are of estuarine origin is made clear by the manner in which the remains of land plants and animals are intermingled with those of estuarine and marine types, just as we find in estuarine deposits at the present day.

I have to acknowledge my indebtedness for much assistance in working out the details of the Gallowhill district to Mr. William Holmes, of Sandyford.

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REVIEWS.

I.—THE ORIGIN OF THE EARTH. By T. C. CHAMBERLIN. 8vo; pp. xi, 271. University of Chicago Press. 1916.

THIS book might appropriately have as a sub-title "The Intellectual Autobiography of a Geological Cosmographer and his Reflections on the Genesis and Geographical Evolution of the Earth". The author has collected into a small monograph the results of his studies of the origin of the earth, and the further development of

his well-known planetesimal theory. The author tells us of the development of his interest in cosmography, and shows us the gradual growth of his present conclusions. He was first led into what he calls the "cosmographic fens and fogs" by his desire to reconcile the existence of former glacial periods with faith in an originally molten globe. He, therefore, with the aid of various mathematical friends, notably Professor Moulton, inquired whether the earth could have been in the condition of incandescent gas; and he was forced to abandon Laplace's nebular hypothesis. In the first series of chapters he points out the objections to it; he claims that it is inconsistent with the kinetic theory of gases, and that if the temperature were high enough to keep the very refractory constituents of the earth in a gaseous state they could not have been held together by gravity. He further holds that if the solar system had originated from a contracting nebula the equatorial velocity of the sun should be 270 miles per second, whereas it is only $1\frac{1}{3}$ miles per second. In reference to the support given to the nebular theory by the practical agreement of the average inclination of all the planets and planetoids to the plane of the solar equator with the requirement that they should revolve in that plane, he objects that the divergence of 5° is greater than should occur. A weightier objection is that though the sun is 744 times as great as all the planets together, yet they, $\frac{1}{7}\frac{1}{4}\frac{1}{3}$ of the mass, own 98 per cent of the momentum. The criticisms of Laplace's theory are undeniably very weighty. Professor Chamberlin admits its attractiveness, and remarks (pp. 61–2) that its long acceptance was the natural result "of its unsurpassed simplicity and beauty, and of the great service it has rendered the progress of thought", and of the "long list of general harmonies between the salient features of the solar system and the broader terms of the hypothesis. On such general harmonies the hypothesis was founded, and from these it gathered to itself a wide adherence".

The older forms of the meteoritic theory Professor Chamberlin also regards as unsatisfactory. He insists that Sir George Darwin's well-known demonstration that a swarm of small meteorites would behave physically as a gas in which each meteorite would act as a molecule rests on the doubtful assumption that the separate meteorites should have an elastic recoil like molecules. Professor Chamberlin's presentation of his own hypothesis is not free from serious difficulties, and is perhaps less attractive than in its original form. The planetesimals now play a comparatively small part. Professor Chamberlin regards the meteorites as fragments of an old world rather than as the germs of a new. He derives the solar systems from spiral nebulæ; and he attributes the latter to the scattering of the material of compact stars by that process of dynamic disruption the possibility of which was indicated by Roche. If two bodies approach one another their mutual attraction produces an internal tide that may break the surface and lead to the escape of a large mass of material through a solar prominence. The matter thus drawn upward may fall back to the parent body as a colossal deposit of volcanic agglomerate; or it may be raised so high as to remain suspended between the two bodies and revolve around the parent as

a planet; or it may be captured by the attracting star and become its planet; or finally it may be shot off into space and escape from the influence of both bodies and give rise to a comet or swarm of meteorites. The tide may cause projections at opposite sides of the parent star, and the matter shot out may, it is held, remain connected to the parent by a nebular band, and thus give rise to a spiral nebula with the usual two arms. Professor Chamberlin suggests that the detached nebulous mass of the nebula M 51 in the constellation of the Hunting Dogs was due to a mass which was torn from the main nebula by the disruptive approach of another star and was left connected to it by a nebulous band.

According to Professor Chamberlin's theory, as the spiral nebulæ are due to the dynamic disruption of a compact and possibly cold star, they do not represent the original condition of matter. They are apparently an ephemeral stage in the life-history of solar systems. The genesis of such systems is therefore pre-nebular. If nebulæ are due either to direct collision or dynamic disruption their life should be comparatively short. The stars which blaze up in consequence of hypothetical collisions lose their sudden brilliancy in a few weeks or months; and if the light of the nebulæ is due to incandescence it ought soon to wane. The author has clearly shown the fundamental difficulties in Laplace's theory; but the nebulæ remain one of the most perplexing enigmas of the heavens. Indeed, several features in the solar system, such as the uniform direction of rotation of the vast majority of its members, in regard to the reasonable explanations that have been offered for the insignificant exceptions, agree better with the requirements of Laplace's theory than with that of the formation of nebulæ by Roche's dynamic disruption.

The second part of the book deals with the less speculative problems of geographical evolution, and it is interesting to note that the author, approaching the subject by his special route, lays much stress on the arrangement of the continents and the oceans as six interlocking triangles arranged around the Equator, on the antipodal position of land and water, and on the periodic variations of the major geographical processes in consequence of the deformation of the earth's crust. These views have been advocated in connexion with the tetrahedral hypothesis, to which the author does not refer. The conclusion in this part of the work to which many geologists are most likely to dissent is the adoption of the permanence of oceans and continents in an extreme form. The author attributes the position of the major elevations and depressions on the earth's crust to influences which acted upon it during its primary consolidation. Lord Kelvin adopted that conclusion and attributed the continents to segregations in the earth while it was still gaseous. Professor Chamberlin suggests they may be due to certain parts of the earth's surface having been cooled by descending currents of air in the anticyclones of the earth's primitive atmosphere.

The book deserves attention by all geologists interested in the early history of the earth, and can be read with interest by any student of either geology or geography. It gives comparatively few references; but those given are of special use to geologists by

directing attention to astronomical and dynamical memoirs which they may easily overlook. The fewness of references is part of the method of the book. Its attractiveness is largely due to the personal element in it, which shows the mental processes by which the author felt his way from the problems of glacial climates to his illuminating contributions to the pre-geological history of the earth. J. W. G.

II.—The Dunstones of Plymouth and the Compton-Efford Grit. By R. H. Worth, M. Inst. C. E., F.G.S. Transactions of the Devonshire Association for the Advancement of Science, Literature, and Art, xlviii, pp. 217–59, 1916.

In this paper the author sets forth some very revolutionary views regarding the Devonian igneous rocks of the Plymouth district. These rocks ("the Dunstones") are described by Mr. Ussher and Dr. Flett in the Geological Survey memoir of the Plymouth and Liskeard district as pillow lavas (spilites), diabases, and schalstein tuffs. The present author, however, comes to the conclusion that the rocks which he classes together under the old name of dunstones are all intrusive, there being no extrusive lava in the series which he has examined. The pillow structure which they exhibit is attributed to the rolling of parts of the walls of the fissure into the dunstone as it was intruded, since the pillows are generally attached to the main mass of the dyke and are surrounded by a skin of baked slate. The associated cherts, previously described as radiolarian cherts, are regarded as silicified slates, as they only extend over a space of the same extent as the dykes and are often included in the dyke or interbedded with thin layers of dunstone. There are three kinds of metamorphism associated with the intrusion of the dunstones, silicification, chloritization, and dolomitization, which with the baking, affect the surrounding slates, either together or separately in different places. The schalstein tuffs and breccias of the Survey memoir are described as being composite rocks of slate and dunstone, produced by the brecciation of the sides of the fissure, accompanied by the mixture of the slate fragments with the igneous rock. The dunstones are therefore regarded as having been intruded into the slates after they had developed a slaty cleavage. The Compton, Crabtree, and Wearde grits, which have been described as volcanic grits contemporaneous with the pillow lavas, are regarded as ordinary sediments, produced by the weathering of pre-existing igneous rocks, the evidence being drawn both from the mineral characters of the grits themselves and from the variety of the pebbles in the pebble bed associated with the grit and dunstone at Crabtree.

W. H. Wilcockson.

III.—A Synopsis of American early Tertiary Cheilostome Bryozoa. By Ferdinand Canu and Ray S. Bassler. United States Museum Bulletin 96. pp. 88, 6 pls. Smithsonian Institution. Washington, 1917.

As one of the authors explains in his preface, the volume is a foretaste of a larger monograph on Tertiary Polyzoa; and, certainly, this hors d'œuvre whets the appetite for what is coming.

It consists of (1) a short statement of the principles of classification; (2) a systematic synopsis containing diagnoses both of the divisions of higher rank than generic, and of all new genera and species; and (3) figures of the new species.

To the general reader by far the most interesting section is the two pages devoted to the principles of classification; though the actual systematic scheme carries much that is of interest to the worker of Polyzoa, particularly to the specialist of Tertiary forms. And it is satisfactory to note, in this connection, that the fundamental divisions of the Cheilostomata adopted by Levinsen have been accepted here. The plates, too, call for congratulation, being, apparently, photographic reproductions of the originals, and, as such, are comparable with the excellent microphotographs of Cretaceous Polyzoa published by Brydone in the Geological Magazine.

It is a pity that, with the need of establishing many new genera, more accuracy was not obtained in putting together the names. Here, especially indeed, the reviewer, having experienced the difficulties involved, would temper his criticism with sympathy. If the Latin ending -ella be permitted to Greek stems, the names *Otionella*, *Dacryonella*, *Aechmella* and others are both pleasant to hear and easy to pronounce; but not so *Stomachetosella*, which is also incorrectly formed, as are *Stamenocella* and *Trematoichos*. But *Metroperiella* is impossible, for *περί* is followed by nothing but a diminutive ending. *Metracolposa* and *Schizaropsis* would be more correct if, in the former, the first *a* were *o* and the final *a* dropped, and, in the latter, the second syllable omitted. *Velumella*, though sounding well, is an impossible form (*Velella* is, of course, preoccupied). What Lewis Carroll would have called the 'portmanteau' words *Membrendœcium* for "Membranipora with endozoœcial avicularia", *Cribrendœcium* for "Cribrilina with endozoœcial ovicells", *Schizemiella* —"'*schizos*,' slit" (there is no such word as 'schizos'), "'*emi*,' abbreviation for peristomie" (not very obvious!)—, and *Schizomavella* —"'mav,' abbreviation for median avicularium," whether pleasing or not, are ingenious. To take one more case—*Metradolium* should have *o* instead of *a*, and even then should mean "a thing that deceives its mother—(or ovicell)", and not "a deceptive ovicell", as intended.

It is impossible in a short notice to discuss adequately the principles of classification adopted. Possibly a better opportunity for this will arise when the larger monograph is published. Meanwhile we would offer our best wishes to the authors for their coming work, and our congratulations on its little forerunner.

W. D. L.

IV.—Brief Notices.

1. (1) Bibliographie primitive relative aux Bryozoaires. By F. Canu. Bull. Soc. Géol. France, ser. 4, vol. xv, pp. 287–292. 1916.

(2) Bibliographie paléontologique relative aux Bryozoaires du Bassin de Paris. By F. Canu. Bull. Soc. Géol. France, ser. 4, vol. xv, pp. 293–305. 1916.

(3) Les Bryozoaires fossiles des terrains du sud-est de la France. IX. Aquitanien. By F. Canu. Bull. Soc. Géol. France, ser. 4, vol. xv, pp. 320–334, pls. iii, iv. 1916.

(1) In the first of these papers, M. Canu gives a list of works dealing with Polyzoa from the years 1555–1792 inclusive, thus rendering available for students primitive works that otherwise may escape their notice.

(2) The second is a bibliography of the Eocene Polyzoa of the Paris basin, with lists of the species mentioned; for the sake of completeness, works dealing with Belgian and British Eocene forms also are included.

(3) In the third, M. Canu produces his ninth contribution to the Tertiary Polyzoa of S.W. France, namely those of Aquitanian age. Nine new species, illustrated in the plates by photographs of the originals, and one new genus are described.

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2. The Physical Conditions indicated by the Flora of the Calvert Formation. By E. W. Berry. U.S.A. Geological Survey, Prof. Paper 98–F, pp. 61–70, pls. xi–xii. 1916.

THE Calvert formation consists of diatomaceous earth, sandy clays, and marls, typically developed in Maryland. Owing to the quantities of diatoms present, there appears to have been assumptions in some quarters that a cold climate was indicated for the region at the time of their deposition. The most abundant plant remains are these diatoms, which have been much studied by experts, who have identified a large number of species indicating a habitat of relatively warm or sub-tropical temperature. The land plant species number twenty-six, of which twenty-three are Dicotyledons. Dr. Berry gives tables comparing these species both with the most similar fossil forms and the nearest living species, and concludes that they indicate "warm-temperate affinities comparable with the existing coastal floras of South Carolina and Georgia". The age of the flora is Middle Miocene or Tortonian.

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3. The Geological Factors affecting the Strategy of the War and the Geology of the Potash Salts. By Professor J. W. Gregory. Trans. Geol. Soc. Glas., xvi, pp. 1–33, 1916.

THE importance of coalfields in war strategy has been severely demonstrated by the occupation by Germany of the French, Belgian, and Polish fields, and to this topic Professor Gregory gives first place. He points out that "when the Peace Congress assembles, its meeting room might be appropriately provided with a geological map of Europe and Western Asia, since the resettlement of the frontiers will be largely dependent on geological influences, of which the diplomatists may have no conscious knowledge". The distribution of oilfields and of copper and iron ores is also discussed in relation to the War, but the most valuable part of the paper from the point of view of geologists is that which deals with the great German potash deposits. Their origin is dealt with and illustrated by many useful sketch-maps and sections, and much information

published in a large paper by Everding in 1907 becomes available in English for the first time.

4. The Banket. By Robert B. Young. Gurney & Jackson, 1917. 8*s.* 6*d.* net.

As the formation, or rather the series of formations, responsible for the world's greatest goldfield, the banket of the Rand has naturally received much attention from geologists as well as from the miner, whose interest is purely economic. Professor Young's book is essentially a petrographic account of the banket and of the associated rocks, concluding with a discussion of the origin of the gold. Allogenic (including pebbles and matrix) and authigenic constituents are separately dealt with, gold being regarded as primarily a member of the former, though afterwards subject to solution and reprecipitation. A noteworthy feature of the book is the profusion and beauty of the plates with which it is illustrated.

5. Correlation and Chronology in Geology on the Basis of Palæogeography. By C. Schuchert. Bull. Geol. Soc. Am., vol. xxvii, p. 491, 1916.

In the first section of the paper the rise of geological chronology is described, and present views regarding the permanency of continents and oceans, and the bearing of diastrophism on chronology, are discussed. It is stated that crustal unrest is recorded in North America by at least fourteen epochs of mountain-making. Of these eight are "disturbances" of lesser import, while six are "revolutions" belonging to the more critical periods of the earth's history. The methods in use for the determination of stratigraphical sequence and correlation form the subject of the second section, and those dealt with are the sedimentary, the palæontological, the palæogeographical, and the diastrophic methods. The third section is devoted to the palæogeography of western North America during the Mesozoic Era, and nine maps illustrating the general conclusions are given.

6. On Synantetic Minerals and Related Phenomena. By J. J. Sederholm. Bull. Comm. Géol. Finlande, No. 48, 1916.

By the term *synantetic*, Sederholm proposes to designate those minerals that occur only where two definite minerals would otherwise meet. Such are the reaction rims, kelyphitic borders, and coronas occurring between various femic and salic minerals in basic rocks, and the intergrowth of plagioclase and vermicular quartz (to which the author gave the name *myrmekite* some years ago) that occurs in acid rocks between the boundaries of potash and soda-lime felspars. With regard to the former, which are described in great detail and with very full abstracts of the literature, Sederholm comes to the conclusion that they are referable to metamorphic processes. In the case of myrmekite and other analogous structures, the literature is again quoted at great length and a large number of new observations are placed on record. The various theories are

critically discussed as to whether the structure is primary or secondary, due to volatile fluxes and solutions, to recrystallization in the solid state or to corrosion, whether it is more recent or older than the dynamo-metamorphism of the rocks in which it is displayed, and finally whether it is produced during the waning phase of plutonic activity, or during the beginning of a new phase which brings about the metamorphism of the rocks generated by the earlier phase. The author points out that no theory is wholly satisfactory, but he decides that in many granitic rocks the structure is connected with the consolidation of the magma of the rock in which it occurs. Since, however, myrmekite has crystallized within the borders of another mineral, replacing its substance, it cannot be regarded as primary in the strictest sense of the word. Where it has formed during the later stages of consolidation it is proposed to call the change *deuteric* (the term *paulopost* already used in teaching by Dr. J. W. Evans would serve equally well), as distinct from a *secondary* formation of myrmekite due to processes accompanying a later period of metamorphism.

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7. The Relation of the Titaniferous Magnetite Ores of Glamorgan, Ontario, to the Associated Scapolite Gabbros. By W. G. Foye. Econ. Geol., xi, p. 662, 1916.

THE gabbro laccolith of Glamorgan was intruded into the Grenville Series before the period of granite and nepheline-syenite intrusions described by Adams and Barlow. The latter intrusions gave off pneumatolytic gases which, according to the author, collected beneath the gabbro and slowly penetrated it. The iron and titanium carried by the gases were oxidized to titaniferous magnetite which was deposited beneath the gabbro, while the chlorine and other gases thus liberated passed on and scapolitized the overlying gabbro. The evidence put forward seems to justify the conclusion that the ores were derived from the later intrusions, and not from the gabbro itself.

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8. Are the "Batholiths" of the Haliburton–Bancroft Area, Ontario, correctly named? By W. G. Foye. Journ. of Geol., xxiv, p. 783, 1916.

THE following are the conclusions to which the author arrives:—

1. That the so-called "batholiths" were formed by the concordant injection of granite into a fissile limestone terrane.

2. That this fissility was produced by the pressure of the overlying sediments.

3. That the layers of limestones, lying between layers of molten granite, were permeated by pneumatolytic gases and fluids given off by the granite, and transformed to amphibolites or grey gneisses.

4. That the concordant injection of the granite, accompanied by the upward flow of magma at centres of intrusion, produced the dome-like character of the gneissic areas.

5. That since the term "batholithic" does not describe the true character of these areas, the term "stromatolithic" (*στρωμα* "a layer", *λιθος* "a stone") is suggested in its place.

9. On Primary Analcite and Analcitization. By A. Scott. Trans. Geol. Soc. Glas., xvi, p. 34, 1916.

In this paper Dr. Scott traces the history of the controversy that since 1890 has centred about the origin of analcite in igneous rocks. He summarizes first the arguments against the primary nature of the mineral and secondly the evidence in favour of that view. It is pointed out that there are three ways in which rocks may be modified by the action of alkali material :—

1. During an early stage in the cooling history of a magma, the liquid residuum becomes enriched in sodium-bearing molecules, so that the later portions of the pyroxenes and amphiboles are relatively enriched in that element.

2. At a late stage in the cooling history, phenocrysts already formed may be corroded by the soda residuum ; felspars and nepheline are analcitized and any residual analcite that remains crystallizes out as a primary mineral.

3. At a period subsequent to consolidation the rock may be acted on by juvenile soda-silicate solutions in such a way that felsic minerals are analcitized, while mafic minerals may be recrystallized as soda pyroxene.

REPORTS AND PROCEEDINGS.

Geological Society of London.

1. *May* 2, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following communications were read :—

1. "Supplementary Notes on *Aclisina*, De Koninck, and *Aclisoides*, Donald, with Descriptions of New Species." By Jane Longstaff (*née* Donald), F.L.S. (Communicated by Dr. G. B. Longstaff, M.A., F.G.S.)

Since the publication of a paper by the Geological Society on *Aclisina*, in 1898, a much larger amount of material has come to hand, which has not only added to the knowledge of the species there described, but has also led to the discovery of six others new to science. The diagnoses of these are now given, and a species named by Mr. H. Bolton *Loxonema ashtonensis* is referred to this genus, as several specimens show the characteristic lines of growth.

The total number of species of *Aclisina* is now brought up to twenty-two, and there are besides several varieties. The genus is best represented in Scotland, where the specimens are generally remarkably well preserved, no less than thirteen having the protoconch intact, drawings of which show its somewhat irregular character. A table is appended giving, so far as known, the range and localities in the British Isles and Belgium. A small variety of *Aclisina pulchra*, De Koninck, appears to have continued for the greatest length of time, commencing in the Calciferous Sandstone Series, existing throughout the Lower and Upper Limestone Series and on into the Millstone Grit of Scotland.

Additional observations are also made on *Aclisoides striatula*, De Koninck, showing its variation in size and ornamentation,

as well as its range throughout the Lower and Upper Carboniferous Series of Scotland, its occurrence at Settle and Poolvash, and at Tournai as well as Visé. New drawings are given of De Koninck's type-forms. One of these, as also a Scottish example, has the characteristic sinus preserved. The holotypes of the first described species were not originally selected; that omission is now rectified, with references to the collections in which they are deposited.

2. "The Microscopic Material of the Bunter Pebble-Beds of Nottinghamshire and its Probable Source of Origin." By Thomas Harris Burton, F.G.S.

As shown by the distribution of the heavy minerals, combined with (*a*) the direction of the dip in the cross-bedding, (*b*) the evidence adduced by boreholes and shaft-sinkings, a main current from the west is indicated. In the neighbourhood of Gorsethorpe this current bifurcated, one division flowing eastwards, the other running south-eastwards.

A large quantity of the material is derived from metamorphic areas, as shown by the presence of staurolite, shimmer aggregates, microcline, sillimanite, and kyanite.

The source of the bulk of the material is probably Scotland, and the westward adjoining vanished land, from rocks similar in the main to those of the metamorphic and Torridonian areas known in that country. Minor supplies came from the neighbouring Pennine ridge, and from other surrounding tracts of high land.

The material was transmitted by means of a north-western river and its tributaries, flowing into the Northern Bunter basin. During certain flood-periods this river overflowed across Derbyshire, carrying its load of sediment, much of which was deposited, as it is now found, in the Pebble-Beds of Nottinghamshire.

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2. *May* 16, 1917, at 5.30 p.m., in lieu of the usual reading of papers a lecture was delivered on "British Geological Maps as a Record of the Advance of Geology", by Thomas Sheppard, M.Sc., F.G.S. The lecture was illustrated by lantern-slides and by an important series of early maps from the Society's Collection.

Zoological Society of London.

May 1, 1917.—Dr. A. Smith Woodward, F.R.S., Vice-President, in the Chair.

The Secretary, Dr. P. Chalmers Mitchell, F.R.S., announced with the deepest regret that Mr. Henry Peavot, the Society's Librarian and Clerk of Publications, had been killed in action. Mr. Peavot had entered the service of the Society in 1896, and, after passing through various departments, was appointed Assistant Librarian and Clerk of Publications in 1908, and was promoted to the post of Librarian and Clerk of Publications in 1912. In every way he had gained the esteem and regard of the Scientific Fellows of the Society, and was one of the most valuable and competent members of the Society's staff.